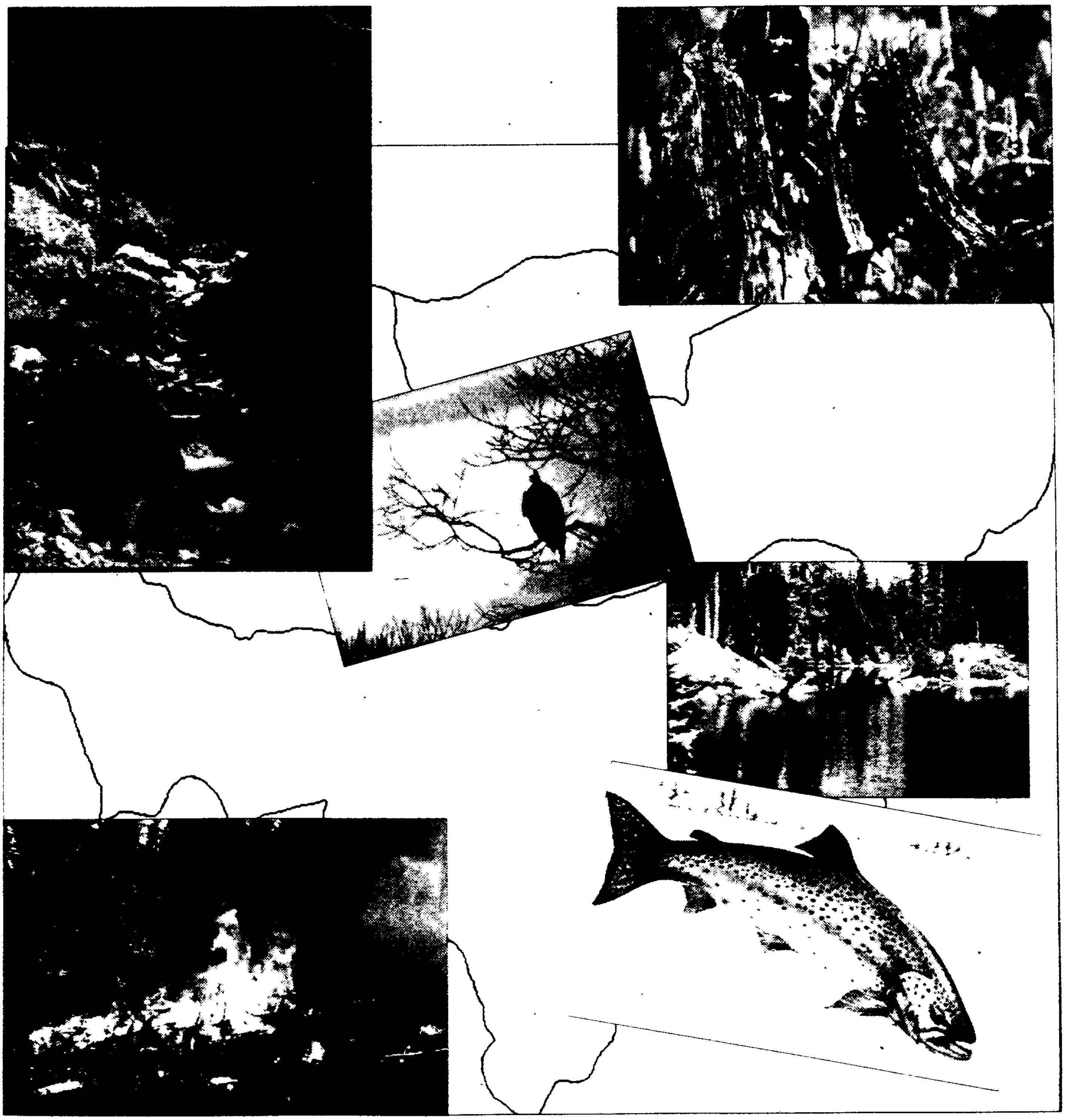
WINEMA S.O. Fisheries

Rock, Cherry and Nannie Creeks

Watershed Analysis

Winema National Forest



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WATERSHED ANALYSIS REPORT
FOR
THE ROCK, CHERRY, AND NANNIE CREEK WATERSHED AREA

I. INTRODUCTION

This report documents an analysis of the Rock, Cherry, and Nannie Watershed Area. The purpose of the analysis is to develop a scientifically-based understanding of the processes and interactions occurring within the watershed area and the effects of management practices. The analysis focuses on issues concerning values and uses specific to the area. These issues form the basis for discussions of the interactions between land-use activities, the physical environment, and its biological components. A detailed outline of the process used can be found in "A Federal Agency Guide for Pilot Watershed Analysis", version 1.2. The analysis was conducted by a four-member core team, which consisted of a hydrologist, soils specialist, fish biologist/aquatic ecologist, and botanist/terrestrial ecologist. Many others were consulted during the process (Appendix A). The analysis was limited by use of existing information on historical and current conditions.

Specific objectives of the analysis are to:

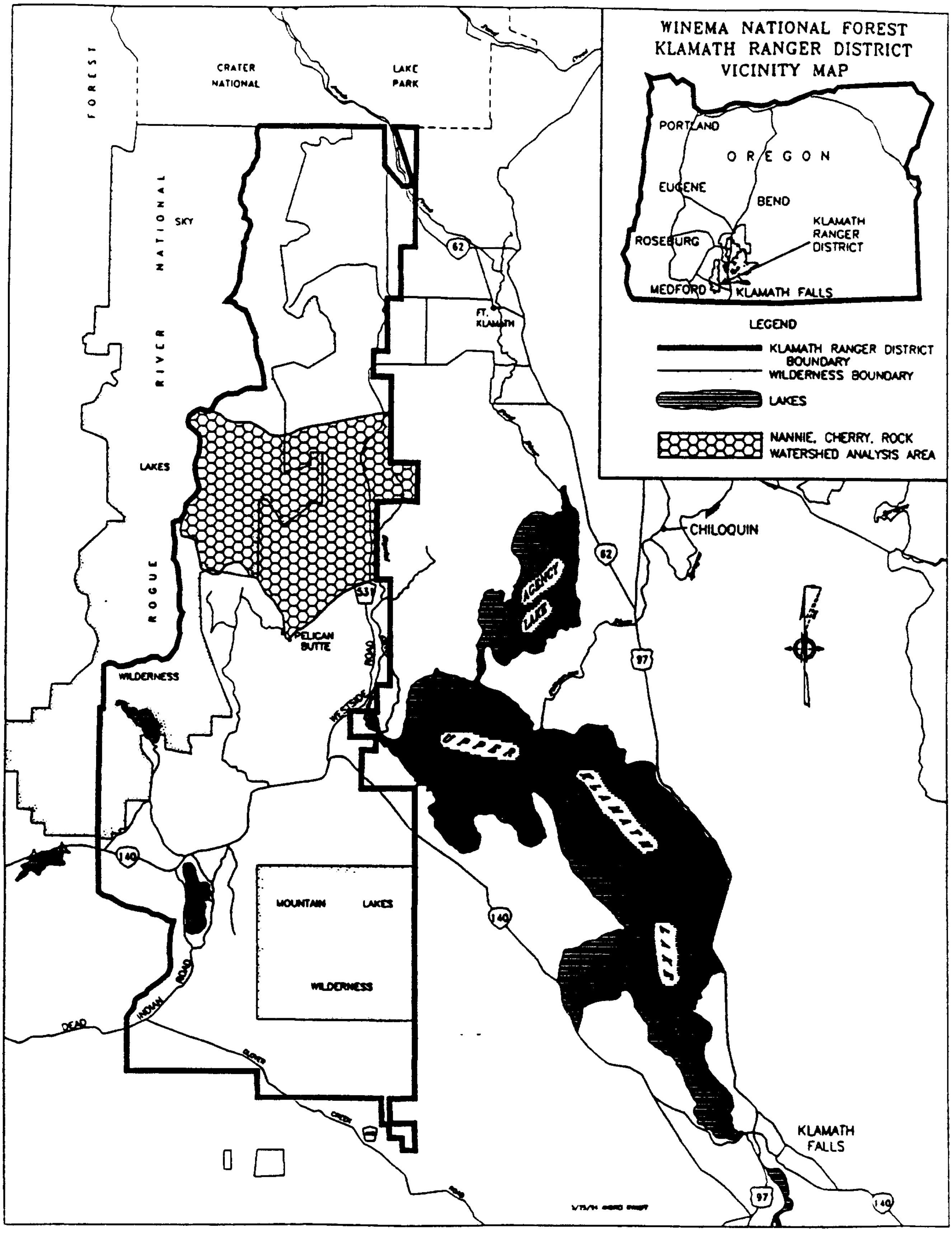
1. Define geomorphological/ecological riparian reserves.
2. Guide restoration and monitoring work in the watershed area.
3. Provide information and recommendations for project planning and management.
4. Develop a framework for future watershed analyses.

II. DESCRIPTION OF THE WATERSHED AREA

A. Location and Land Management

The 29,851-acre watershed area is located in Klamath County, approximately 20 miles south of Crater Lake National Park and 30 miles northwest of Klamath Falls (Map 1). It includes the drainages of Rock (Map 2a), Cherry (Map 2b), and Nannie (Map 2c) Creeks, which originate at the crest of the southern Oregon Cascades and flow eastward to the Klamath Lake Basin. Elevations range from 8,000 feet at the top of Pelican Butte to 4,100 feet in the basin. The upper portions of the watershed area are entirely within the boundaries of the Klamath Ranger District of the Winema National Forest. The lower portions are primarily in private ownership, which totals approximately 2,800 acres or 9% of the watershed area.

Approximately 12,462 acres of the watershed area are part of the Sky Lakes Wilderness and are included in Management Area 6 in the Winema National Forest Land and Resource Management Plan of 1990 (Forest Plan). This includes the upper-most area near the Cascade crest, and a significant length of the Cherry Creek drainage (Map 3). An additional 1,200 acres of the Cherry Creek drainage outside the wilderness are designated as a candidate Research Natural Area (RNA) and are included in Management Area 13. Three blocks, totaling 190 acres, are managed as old growth (Management Area 7). These occur in the upper and lower Rock Creek drainage. A large portion (3,349 acres) of Pelican Butte in the Rock Creek drainage is managed for semi-primitive recreation (Management Area 1). These four management areas have been little affected by past management activities. They total 17,201 acres and comprise 57% of the watershed area.



MAP 1. LOCATION OF WATERSHED ANALYSIS AREA

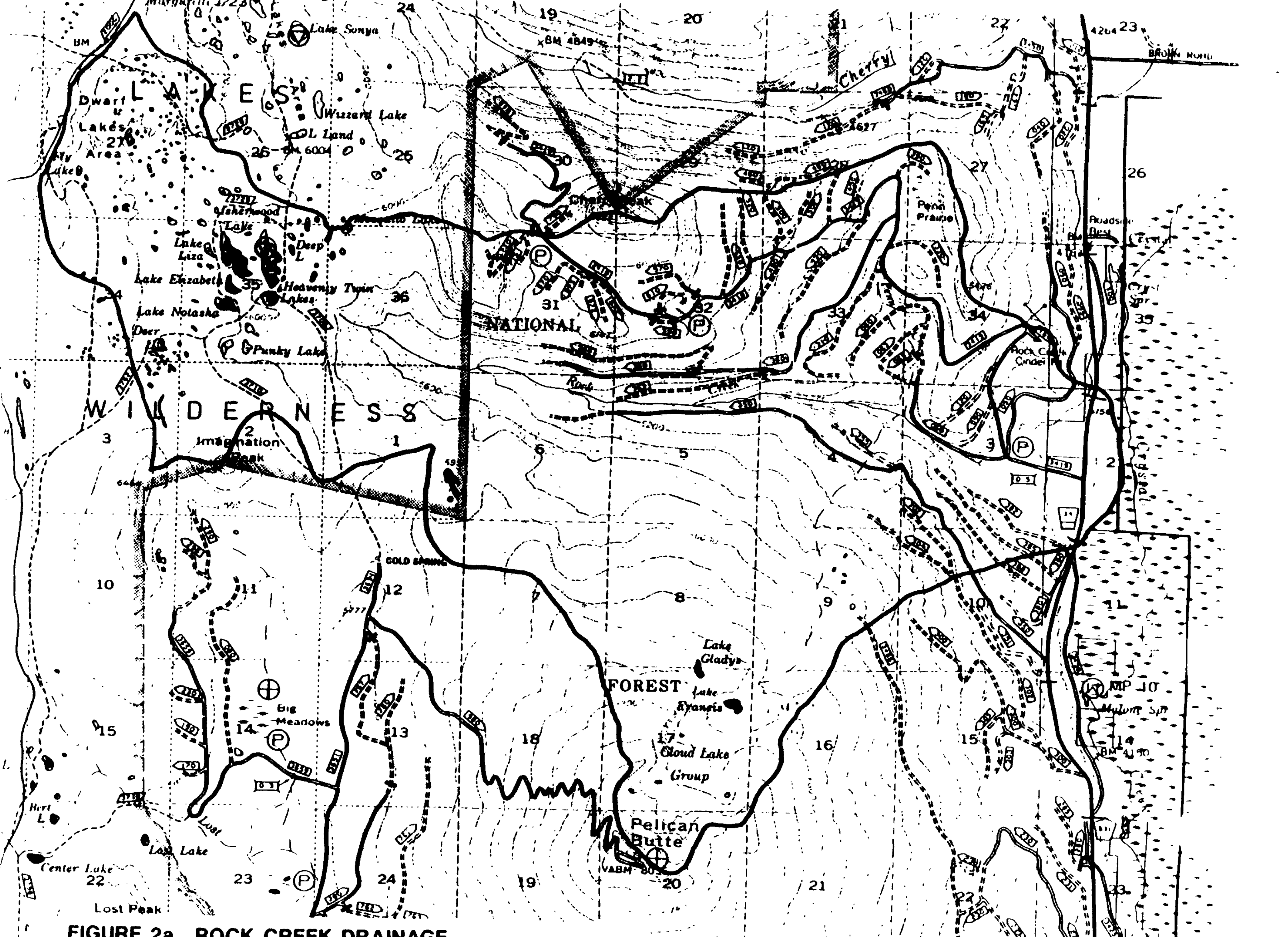


FIGURE 2a. ROCK CREEK DRAINAGE

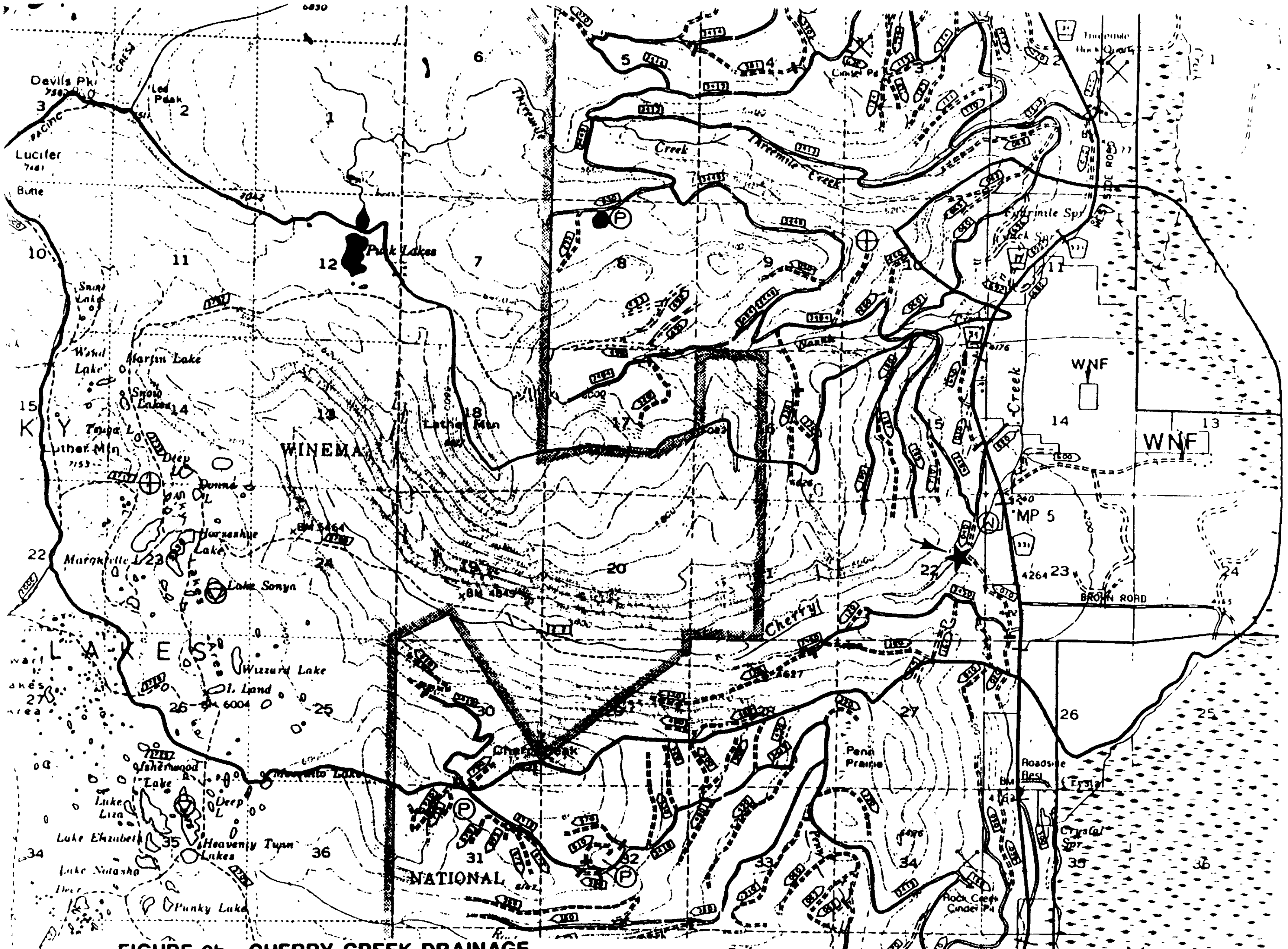


FIGURE 2b CHERRY CREEK DRAINAGE

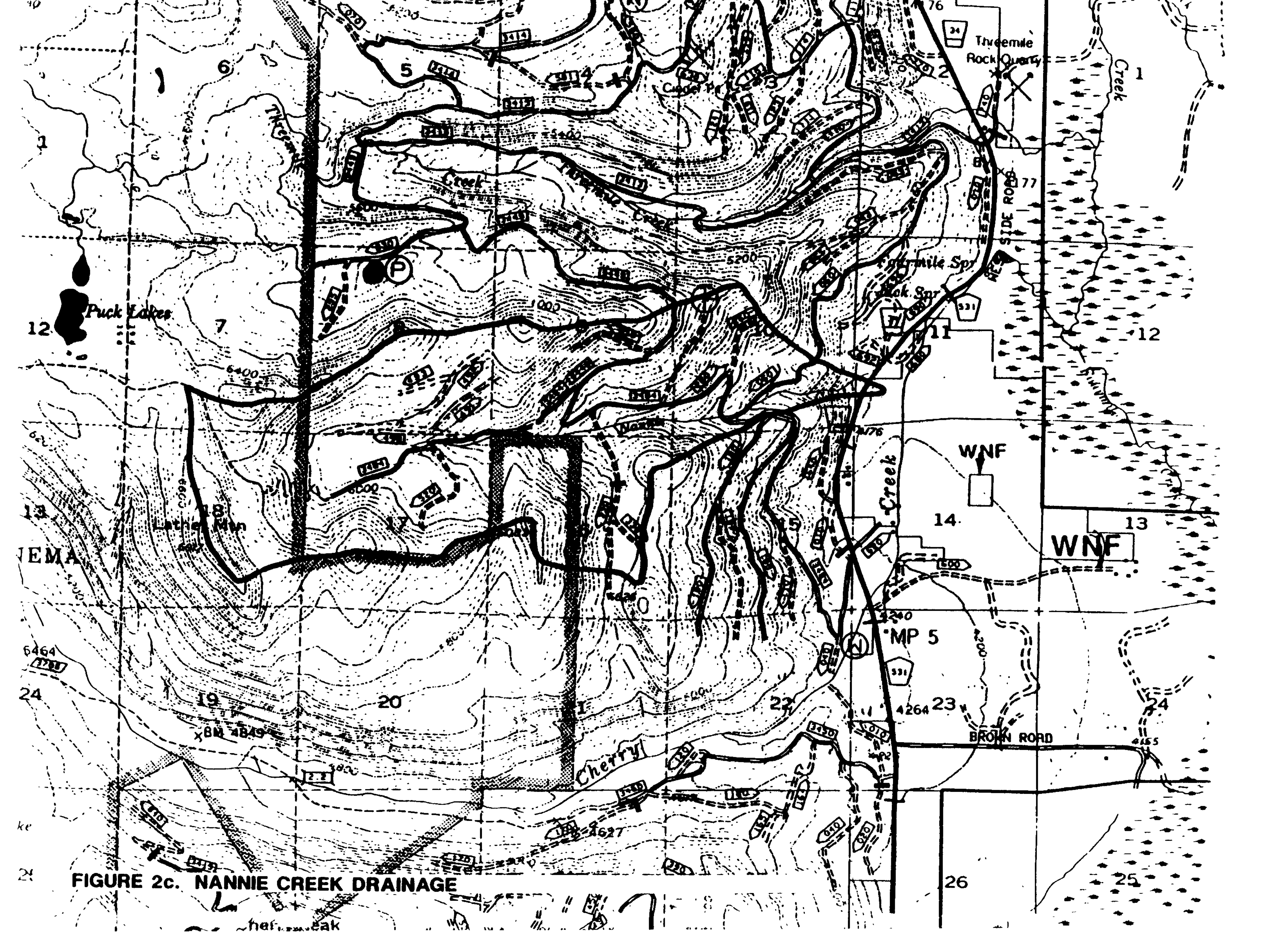
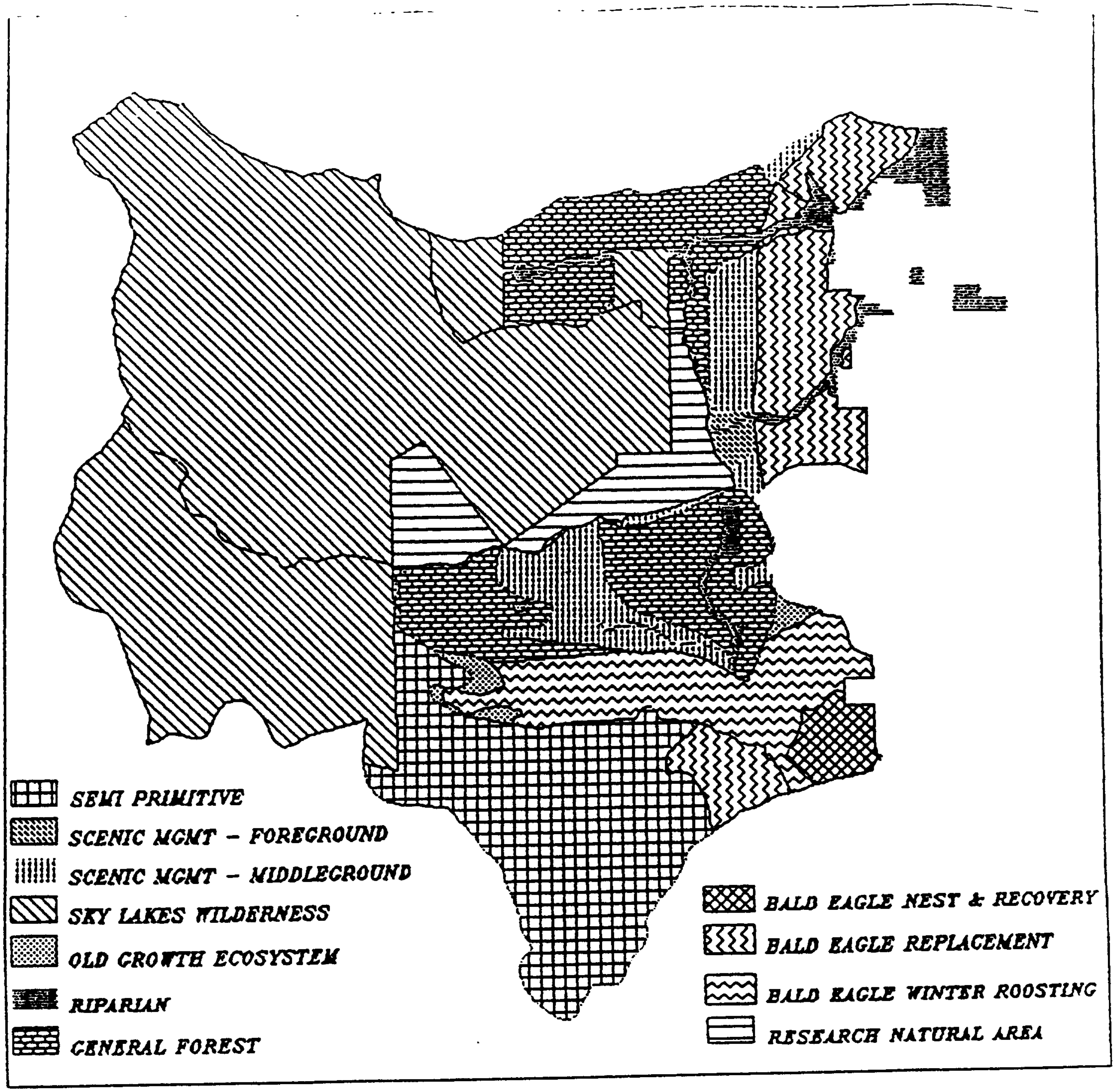


FIGURE 2c. NANNIE CREEK DRAINAGE



MAP 3. WINEMA FOREST PLAN MANAGEMENT AREAS

The remaining National Forest System (NFS) land lies in scenic, timber production, bald eagle habitat, and riparian management areas. A significant amount of timber harvest and road construction has taken place in these management areas during the past 30-40 years.

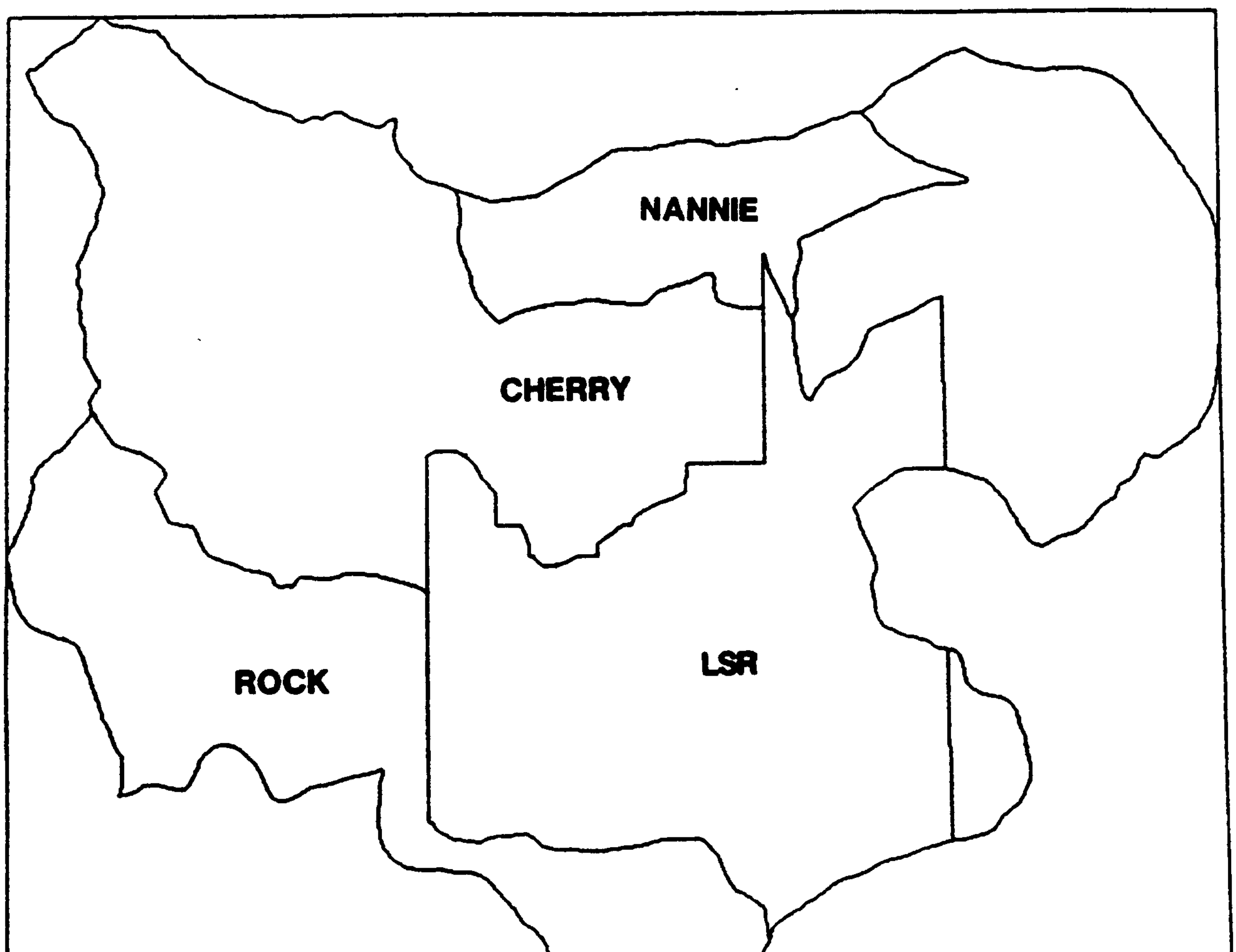
Many of the existing management areas under the Forest Plan are superseded by the designation of Late Successional Reserve (LSR) and matrix lands in the Final Supplemental Environmental Impact Statement on Management of Habitat for Late-Successional and Old-Growth Forest Related Species Within the Range of the Northern Spotted Owl (USDA Forest Service and USDI Bureau of Land Management, 1994a). Approximately 7,807 acres of LSR are in the watershed, with the majority in the Rock drainage (Map 4). Matrix lands include all areas outside the wilderness and LSR.

B. Geology

The watershed area can be divided into three distinct geographical zones. East of the steep rock escarpments and talus slopes of the Cascade crest, the first zone is the Cascade summit, which features broad, flat, hummocky plateaus with numerous kettle lakes and vernally wet meadows. The second zone is characterized by steep, heavily forested slopes which descend from the summit to the third zone, the lacustrine environment of the Klamath Lake Basin.

The Cascade Range developed from volcanic activity modified by glacial and tectonic forces. Prior to volcanism, the area was covered by marine sediments deposited during the Cretaceous Era. During the Eocene Epoch, volcanic eruptions began in the Cascade region. Subsequently, several shield volcanoes developed, overlaying the mid-tertiary deposits with interlayed flows of basaltic andesites, basaltic pyroclastics, and volcanistic sedimentary rocks. These repeated flows from shield volcanoes comprise the bulk of the Cascades (Carver, 1973). During the Pliocene and Pleistocene Epochs, andesitic stratovolcanoes, such as Devils Peak, matured and coupled with basaltic flows from shield volcanoes to form the wilderness plateaus. Mt. McLoughlin, a composite cone, rose west of the central axis of the Cascades; while on the east, and paralleling the Klamath graben, several cinder cones formed, consisting mainly of olivine basalts. An example is Pelican Butte, a shield volcano capped by a large cinder cone, which forms the southern boundary of the watershed area.

Several glacial events followed, gouging and reshaping the topography laid by the basalts and pyroclastics. At least six glacial events have been observed in the area. On the summit plateaus, glacial activity formed closed depressions in thick morainal deposits. A sequence of progression and ablation of glacial ice, each further downcutting into the previously laid volcanic deposits, formed glaciated valleys which radiate from the Cascade summit. Most noteworthy of these glacial events is the Varney Creek drift. Deposits from this drift are very large in both volume and spatial extent. Composed of cobbles and boulders of weathered basalt and andesite, thick layers of till were deposited in glacial valleys extending into the marshlands on the east side of the Cascades. Subsequently, large streams eroded the Varney Creek till, carving deep V-shaped valleys, including the Rock, Cherry, and Nannie Creek drainages. In the marsh, the Varney Creek debris was covered by fluvial and lacustrine deposits.



MAP 4. LOCATION OF LATE SUCCESSIONAL RESERVE

High angle normal faulting ensued, contorting and separating volcanic rocks and glacial deposits. These faults are oriented north-south and generally dip toward the east. They are part of the system of normal faults which define the western margin of the Klamath graben, a major late Cenozoic structural feature of the northwest Great Basin (Carver, 1973). The most recent major event was the eruption of Mt. Mazama 6,500-7,000 years ago, which blanketed the Cascades with pumicous ash. The ash was deposited deepest to the north and east and forms a thin layer in the watershed area.

C. Climate

Cold, snowy winters and warm, dry summers characterize the climate of the watershed area. Precipitation is greatest during December to January and falls primarily as snow (Carlson, 1979). Deep snowpacks can accumulate, particularly at the higher elevations. The timing of peak runoff is determined by spring rains; the duration is a function of snow pack. Rain-on-snow events occur infrequently. A 100-year flood resulted from a rain-on-snow event in 1964 (Christmas flood). Significantly lower amounts of precipitation fall during the summer, concurrent with moderate to high temperatures. Thunderstorms occur frequently in the summer. Due to the rain shadow effect of the Cascades, annual precipitation decreases moving east from the crest. Average precipitation ranges between 60 inches per year near the crest and 25 inches per year at the lower elevations.

D. Soils

Unnamed soils of the "X" group (Carlson, 1979) formed from glacial till in the uplands of the Sky Lakes Wilderness and bottoms of the Cherry Creek valley and upper Rock Creek valley, where slope gradients are less than 35%. This group consists of well-drained gravelly to very gravelly and cobbly sandy loams and loamy sands. Gravel, cobble, and stones make up 15-75% of the soil material. Depth to bedrock is generally greater than 40". However, in many areas, impervious dense glacial till or mudflow material underlies the soil at fairly shallow depths. This limits rooting depth and water storage space and increases the chance for runoff.

Unnamed soils of the "R" group, derived from a mixture of volcanic ash, weathered andesites, basalts, mudflows, and pyroclastics, are found on the upper to lower slopes of all three creeks. The R group consists of well-drained gravelly and cobbly fine sandy loams and loam soils. Gravel, cobble, and stones make up 10-75% of the soil material. Slope gradients range from 0-70%. Soils on concave slope positions tend to be less rocky, while those on steeper slopes are higher in coarse fragments. Depth to bedrock is generally greater than 60 inches and rooting depth 20-40". R group soils have the highest productivity potentials of any on the District and the greatest potential for reduction in productivity due to management activities (Carlson, 1979). Soils with more than 60% coarse fragment content are unplantable and difficult to regenerate. Soils with less than 50% coarse fragment content are susceptible to compaction when moist. Soils on steep slopes have a potential for severe sheet erosion.

Where the creeks reach the Klamath Lake Basin, cobbly glacial outwash fans have formed. These areas are classified as landtypes 7 and 9. The landtypes have slopes of 0-15%. Soils are gravelly to very gravelly and cobbly sandy loams and loams. The coarse fragment content is 20-50%. Depth to bedrock is greater than 96". Landtype 7 is somewhat poorly drained, while landtype 9 is well to moderately well drained.

E. Hydrology

The three creeks drain the east side of the southern Oregon Cascades and are tributary to Klamath Lake. Rock and Cherry Creeks are third order drainages; Nannie Creek is a second order drainage.

All three creeks have snow melt-dominated hydrologic regimes, with elevations ranging from 8,000 to 4,100 feet. The mean basin gradient is quite high in all three drainages. Consequently, tributaries and much of the main channels have erosion-dominated processes. Discharge velocities are high enough to transport sands and silts to the alluvial fans of the lower reaches. Valley bottom widths are narrow with little floodplain development. Streamside sediments are predominately colluvial in nature, breaking away from steep sideslopes of glacial till.

The high glaciated plateau, known as the Sky Lakes Basin, has several wet meadows and lakes. A few of these lakes have a closed hydrology system (no open channel inflow/outflow) and therefore contain exceptional water quality. The summit plateau is also a recharge zone. The underlying bedrock geology is fractured in a north-south orientation and dips to the east. A combination of water retention, fractures, and steep hydraulic gradients minimizes surface flow. As snow melts, water is routed via fissures with strong hydraulic gradients to deep aquifers; discharge occurs at the geologic nick point between the declivities of the Cascade Range and the Klamath Lake Basin. Numerous springs (e.g., Malone, Crystal, Jack, Mares Egg, and Fourmile) occur at this point, and provide a significant input of quality water to the littoral and lake ecosystems.

F. Potential Vegetation

Three different forested vegetation zones (Franklin and Dyrness, 1973) occur in the watershed area (Map 5). Each contains more than one locally recognized plant association as described by Hopkins (1979). The mountain hemlock zone comprises approximately 8,220 acres located at the upper elevations near the Cascade crest and the top of Pelican Butte. Plant associations include mountain hemlock/grouse huckleberry; lodgepole pine/grouse huckleberry/long stolon sedge; and Shasta red fir-mountain hemlock/pinemat manzanita/long-stolon sedge, which overlaps the Shasta red fir vegetation zone. Several non-forested communities also occur in the mountain hemlock zone. These include moist to wet meadows dominated by tufted hairgrass and/or various sedges and ringed by riparian shrubs, as well as many lakes and ponds with aquatic and riparian vegetation.

The mountain hemlock zone grades into the Shasta red fir zone at roughly 6,000 feet elevation. Approximately 7,514 acres lie in this zone. Plant associations include the previously mentioned Shasta red fir-mountain hemlock association, as well as Shasta red fir/long stolon sedge and Shasta red fir-white fir/chinquapin-princes pine/long-stolon sedge. Forested riparian areas in this zone often have significant amounts of white fir, Engelmann spruce, Douglas-fir, and mountain hemlock.

The white fir zone occurs at approximately 5,500 feet elevation and extends to the Klamath Lake Basin. It is the largest zone, covering 11,626 acres. Upslope and north-facing forests are primarily white fir/chinquapin-boxwood-princes pine, while those on the lower, east, and south-facing slopes are mixed conifer/snowbrush-pinemat manzanita. A poorly-defined and highly variable white fir-alder/shrub meadow association occurs along the creeks.

MAP 5. FORESTED VEGETATION ZONES

Miscellaneous wetland types occur on portions of the glacial outwash fans of Cherry and Rock Creeks and surrounding areas (1,405 acres). Lodgepole pine/huckleberry/forb swamps; Kentucky bluegrass-dominated moist meadows; sedge-dominated wet meadows; tule marsh; and aspen, cottonwood, and willow groves are present in this lower area.

III. BENEFICIAL USES AND VALUES

A. Biodiversity

Both the geographical location and wide range of elevations, landforms, and aspects contribute to the biodiversity of the watershed area. The watershed area contains potential habitat for 290 species of vertebrates documented or expected to occur on the Klamath Ranger District (Appendix B). These include several sensitive, candidate, and Federally-listed species: redband trout, bull trout, northwestern pond turtle, Cascade frog, spotted frog, marten, California wolverine, North American lynx, Pacific western big-eared bat, northern spotted owl, bald eagle, goshawk, greater sandhill crane, and yellow rail. Fifty-six vertebrate species associated with late seral habitats have been documented or are expected to occur. Surveys have not been conducted for invertebrate species, and little information is available at this time.

Almost 400 species of vascular plants have been documented or are likely to occur, based on surveys of similar habitats (Appendix C). This includes the sensitive species Newberry's gentian, sticky catchfly, and Mt. Mazama collomia. Thirty-two of the vascular plant species are associated with late successional habitats. Limited information is available about fungi in the watershed area, although observation suggests the Cherry Creek drainage is particularly rich in fungi. Over 80 species may be present, including 14 species associated with late successional stands. Surveys have not been conducted for lichens and bryophytes.

B. Wilderness/Research Natural Area.

The watershed area contains 12,462 acres of the Sky Lakes Wilderness. Wilderness uses and values include: primitive recreation experiences, scientific and educational uses, a benchmark for ecological studies, and the preservation of historical and natural features. When established, the Cherry Creek Basin RNA will encompass 9,670 acres of the watershed area (including Management Area 13 and a portion of Sky Lakes Wilderness) and preserve representative areas that typify nine forest, alpine, and aquatic community cell types. The RNA will provide a reference area for comparing results from the effects of resource management techniques and practices outside the RNA, opportunities for on-site and extension educational activities, and a reserve for the preservation and maintenance of genetic diversity and biodiversity as a whole.

C. Recreation

The watershed area provides opportunities for several recreation activities, including hunting, fishing, camping, backpacking, hiking, horseback riding, mushroom hunting, cross-country skiing, and snowmobiling. Elk, mule deer, bear, cougar, and waterfowl are the primary game species. Anglers fish in Cherry Creek and in stocked subalpine lakes in Sky Lakes Wilderness. Dispersed vehicle camping is concentrated near the Cherry Creek irrigation diversion. Semi-primitive camping occurs near many of the wilderness lakes.

Several trails are present. The Cherry Creek Trail and Nannie Creek Trail follow their respective drainages to the Cascade summit, where they tie in with the north-south Sky Lakes Trail, Pacific Crest Trail, and other trails around the major lakes. Use of the Cherry and Nannie Creek Trails is light to moderate, with most visitors using the Cold Springs Trail, which accesses the watershed area from the south. The larger wilderness lakes (Notasha, Heavenly Twins, Isherwood, Margurette, and Trapper) are the most popular wilderness destinations. Areas away from the trails and large lakes receive little use. The Cherry Creek Trail is used in winter for cross-country skiing. The Diamond Lake Snowmobile Trail runs from the west side of Pelican Butte north through the non-wilderness portion of the watershed area.

D. Cultural Resources

Human occupation of the watershed area began in prehistory and carries through into the recent historic era. The use of the watershed has likely changed in both intensity and nature. The watershed appears to have been the focus of permanent settlement, religious, recreational, and in more recent times, logging activities.

Earliest uses of the watershed area appear to include permanent habitation during the prehistoric era. Spier (1930) and Gatschet (1890) document that a division of the Klamath Indians (known as the gu'mbotkni) was settled in the area of Pelican Bay and that other settlements belonging to this group were located along Sevenmile Creek. Presumably, inhabitants of the Rock/Cherry/Nannie area belonged to this group; neither Spier or Gatschet make mention of settlements in this area. Additionally, the area was used for religious activities as evidenced by several vision quest sites found within or near the watershed boundaries.

Important characteristics of the watershed area which would have been attractive to native peoples include resident fish populations, abundant sources of fresh water (streams, lakes, and springs), and diverse wildlife and plant populations supported by the ecosystems found in the watershed. In terms of the religious uses of the watershed, its general topography affords views of the surrounding landscape and important geographic places from high peaks and prominences. Also, pools of water (springs, lakes, and possibly pools in streams) are believed by the Klamath to be the residences of spirits and were swum in for the sake of gaining power.

Historic era activities within the watershed area include logging and ranching. The earliest white settlers in the area were members of the Daniel G. Brown family, who built a house near Crystal Spring in the early 1890s. Following the arrival of the railroad in Klamath Falls and steamboats on Klamath Lake in 1909, Crystal Creek was dredged and became a major travel route for tourists traveling to Crater Lake. Improved navigability up Crystal Creek promoted large-scale timber operations. The Browns were involved in early lumbering activities, and were among the first to use barges and log rafts on Crystal Creek. Cordwood was barged to Klamath Falls, while log rafts were taken to mills across the lake at Algoma and Shippington (Farnell, 1980). Although considerable volumes of timber were shipped out of Crystal Creek, it is unclear whether the logging was conducted on private lands or on NFS lands. A Christmas tree sale bought by the Browns in 1913 was the first commercial sale on NFS lands in the area. In order to facilitate logging enterprises in the area, the Brown family constructed a sawmill near Crystal Spring sometime between 1914 and 1925 (Farnell, 1980), from which lumber was shipped to railroads near Klamath Falls.

In addition to the activities of the Brown family, the newly formed Crater National Forest established a ranger station near the mouth of Cherry Creek in 1910. Little information is available regarding the activities administered from the Cherry Creek Ranger Station, and although a cabin is reported to have been built there, nothing remains of the station today. As was the case with many of these early ranger stations, the Cherry Creek station was probably used primarily as a post for summer crews, who spent the bulk of their time building and mending fences, trails, and telephone lines, and fighting fires.

Early recreational uses of the watershed are attested to by the presence of at least three cabins reportedly built by hunters. Two of these are possibly from the early part of the century, while the third is known to have been constructed in the 1960's by a local man, who intended to use it while hunting in the area.

E. Timber and Roads

Timber harvest began in the early 1900's soon after settlement of the area. At that time, the focus was on removal of large ponderosa pines in the lower Cherry drainage. By 1940, many of the private stands and a few of the Forest Service stands adjacent to the main road (Westside Road) had been partially cut. More extensive timber harvest began on NFS lands in the 1950's, peaked in the 1960's, and continued until the early 1990's. In the 1950's and 1960's, the dominant harvest prescriptions were overstory removals of large ponderosa pine. With changing markets, utilization of large white fir became feasible in the 1970's, leading to overstory removals of all species. Thinnings of immature white fir stands were conducted in the 1980's, as smaller diameter trees became merchantable. The clearcuts present in the watershed area were done during the 1980's, as well. Approximately 15,300 acres of NFS land have been logged, including multiple entries, and roads have been built to access the units. The watershed area currently has 76.5 miles of roads. Under the Forest Plan, approximately 9,300 acres of NFS land are considered to be suitable for timber production (31% of the watershed area). This currently represents a total standing volume of roughly 115 MMBF.

F. Agriculture and Water Source

The private lands in the lower portion of the watershed have been used for ranching since they were first settled in the early 1900's. Cherry Creek was diverted and channelized for agricultural use soon after settlement. The Browns pulled stumps and logs out of the creek and used dynamite to straighten and deepen a main channel. An extensive system of irrigation and drainage canals was begun in the 1920's to improve fields and pasture lands and mitigate the effects of installation of the Linkville Dam on Upper Klamath Lake, which raised water levels 3.3 feet. Both Sevenmile and Fourmile Creeks were dredged at that time. Fourmile Creek was also diverted south into Agency Lake. Shortly after creation of the Sevenmile and Fourmile canals, the main branch of Cherry Creek was directed north into the Fourmile canal, providing a permanent conduit to the lake. Haying and cattle grazing were the main agricultural uses on private lands in this area, and continue today. In the past, sheep were also grazed.

Almost all NFS lands in the watershed area were grazed by cattle until the mid 1970's. Cattle roamed the upland areas without pasture fences or herding, probably concentrating in the bottom of the Cherry Creek drainage, open harvest units, and wilderness meadows. In the low elevation areas, two grazing allotments remain, totaling approximately 1% of the Cherry Creek drainage. The Jack Springs allotment encompasses 145 acres of mostly moist-wet meadow habitat. This area has been seeded and used for haying as well as grazing. Currently 160 head are grazed from July to September. Roughly 1/4 of the 100-acre Fourmile Springs allotment also lies within the watershed area, north of Fourmile Springs. This allotment consists primarily of moist meadow, but includes forested land and wet meadow, as well. A portion of the allotment was used as a feedlot in the past; haying of native species also occurred. Currently 50 head are grazed from July to October.

G. Mineral Resources

It is unlikely that the watershed area contains significant metallic mineral or geothermal energy resources. Likewise, the geology of the area is not favorable for coal, oil, or gas resources (Smith and Benham, 1984). Volcanic cinders, scoria, ash, and breccia which could be used in road construction, along with sand and gravel, are present. Currently there are two gravel/rock pits located on NFS land and three on private land.

H. Aesthetic/Scenic Values

The watershed area has exceptional aesthetic quality. Among the outstanding aesthetic features is the feeling of solitude forest visitors can achieve within certain portions of the area, particularly the Sky Lakes Wilderness. It is uncommon in today's world to be able to linger in a location where one cannot see or hear another human sight or sound for several hours at a time, as can occur here. One can also find locations within the watershed area where nearly complete solitude is possible for several days at a time. This is a highly valued aesthetic resource for many forest visitors.

The watershed area is visible from Crater Lake National Park, near the lodge and from the scenic Rim Drive at background distances. It can be seen from Highway 97 and the City of Klamath Falls, at distant middleground to background distances. The watershed area is also visible from the air to tourists and other passengers on Horizon Air flights to and from Portland at an elevation of less than 10,000 feet, as the planes approach or leave the Klamath Falls airport. The area is seen at foreground distances from the Westside Road and Pelican Butte summit, a semi-primitive recreation area popular with telemark skiers and snowmobilers.

In general, the visual quality of the three drainages is good-to-excellent and meets visual quality objectives. Corridors along the roads to the Cherry and Nannie Creek trailheads have a visual quality objective under the Forest Plan to retain the natural-appearing condition of the foreground areas. This is currently being met. A small portion of the planning area has a modified appearance due to past clearcutting in the Rock drainage, which can be seen from most viewpoints in the area. These openings are clearly seen from the air and are likely candidates for visual rehabilitation, although they do meet Forest Plan standards and guidelines.

IV. ISSUES TO BE EVALUATED

Issues were developed based on the Watershed Analysis Team's own knowledge and interviews with others interested or knowledgeable about the area (see Appendix A for a list of those contacted). The Klamath River Basin analysis was not completed prior to this analysis. The issues likely to come out of the basin analysis will be much larger in scope and complexity than those for this watershed area. The team decided not to develop them in this document for the following reasons: the team did not have the resources to analyze the larger issues; the influence of the Rock, Cherry, and Nannie watershed area on the basin as a whole is minor; and maintaining the processes and functioning of this watershed area will contribute to restoring the processes and functioning of the basin, and is a sufficient goal for this analysis.

ISSUES

A. Forest health has declined in the watershed area.

B. Wildlife and plant habitat has been altered by timber harvest, fire suppression, and diking/draining of wetlands.

C. Subalpine lakes have been impacted by fish stocking and recreation.

D. Native fish populations have been impacted by introduction of exotic fish and alteration of habitat.

E. Fish habitat has been impacted by previous land management activities in Rock, Cherry, and Nannie Creeks.

F. Channel condition has degraded.

G. The hydrograph has been altered, in terms of base flow, peak flow, and timing of peak flow.

H. Increased sediment loading is occurring in the creeks.

V. ANALYSIS OF ISSUES

A. ISSUE: Forest health has declined in the watershed area.

KEY QUESTIONS: What is the natural disturbance regime of different forest types in the watershed area, has it been altered, and has alteration contributed to forest health problems?

Has past harvesting contributed to forest health problems?

DISCUSSION

Mountain Hemlock Zone

Fire is the primary agent of natural disturbance in the mountain hemlock zone (see Map 5). Disease (laminated and Armillaria root rot) may create small gaps, typically less than 1 acre in size. Windthrow is minor and largely confined to ridge tops, areas with shallow soil, or sites with high water tables. According to Agee (1993), the fire regime in the mountain hemlock zone is characterized by a long average return interval (>500 years) and high intensity burns. Fire behavior and extent are often controlled more by weather conditions, stand continuity, and natural barriers (rocks, wet meadows, lakes, ridges, etc.) than fuel loads.

Trees in this zone have little resistance, and fires are often stand-replacing events. Shasta red fir develops moderate resistance to low intensity fires with age, as trees get larger and bark thickens (typically >120 years). Lodgepole pine generally colonizes burned areas, because mountain hemlock seeds in more slowly. Shasta red fir requires an existing partial canopy for frost protection and comes in under lodgepole or mountain hemlock stands.

Leiberg (1900) describes large blackened areas and areas inhabited only by lodgepole pine in the Sky Lakes basin, which were probably burned sometime in the mid to late 1800's. The burned areas are patchy and visible on 1940 and more recent aerial photos. Agee (1993) notes that mountain hemlock (and Shasta red fir) begins to dominate sites after 100+ years. Vegetative typing done in the 1950's indicates that by that time, lodgepole pine was no longer the primary overstory species on the burn sites, and the canopy remained fairly open (26-40% closure). Meadow areas remained constant from 1940-1993. Agee (1993) states that more-or-less permanent subalpine meadows can be created by intense burns. However, meadows in the Sky Lakes Basin generally occur in wet depressions unfavorable for tree growth, and are probably not controlled by the fire regime.

Historically, lightning was the primary cause of fires, although Native Americans may also have set fires. Leiberg (1900) notes that white settlers burned to improve grazing and hunting and set off several accidental fires. Data since 1960 shows a rate of .054 lightning ignitions/1,000 acres/year. The rate of campfire-caused ignitions was slightly higher, .061 ignitions/1,000 acres/year. All of these ignitions were suppressed and none resulted in fires greater than 1 acre. It is probable most would have remained small and gone out without suppression efforts (Augustine, pers. comm.). Given the long return interval for major fires, it is unlikely that fire suppression since 1910 has had much effect on natural stand condition in this zone.

Red Fir Zone

Fire is also the primary natural disturbance in the red fir zone. Disease (Armillaria root rot) creates small gaps, typically less than 1 acre in size. Windthrow is minor. The fire regime is characterized by an intermediate average return interval (40-60 years) and variable intensity and size of burns (Agee, 1993). This creates a small patch structure in these forests. A good example is seen in the upper Nannie Creek drainage, which probably burned before the turn of the century.

Severely burned sites generally convert to brush fields (chinquapin, manzanita, snowbrush) which may remain for several years (50+) before red fir re-establishes. Aerial photos from 1940 show 10 brush patches in the red fir zone averaging 26 acres in size (range 6.6-60.9 acres). These occur on south-facing slopes in all three drainages and comprise 3.5% of the area. By 1993, most of the brush fields had partially filled in with trees, but canopy closure generally remained low (<40%). Lodgepole pine and western white pine can also colonize open sites. Ponderosa pine is an early seral species in the lower portion of the zone, but its range is limited by snow loading in the upper elevations.

Low intensity fires may be more common than high intensity fires in the red fir zone (Agee, 1993). Low intensity fires thin out mature red fir stands, create gaps for regeneration, and promote development of multi-layered canopies. Red fir regeneration typically forms dense stands in gaps and under remaining partial canopies.

Lightning is the main source of ignition in the red fir zone and probably was historically as well. Data from the past 34 years shows an average of .063 ignitions/1,000 acres/year caused by lightning and .016 ignitions/1,000 acre/year caused by humans. Of the 20 ignitions that have occurred since 1960, 1 resulted in a 5-acre fire; the remainder were less than 1 acre in size. All were suppressed.

At this point, the length of time since fire suppression activities began is probably within the range of fire return intervals for the red fir zone in this area, and has not had much effect on forest health conditions. Mortality from root rot remains low. Only 21 acres of stands sampled with stand exams in this zone currently have high root rot infection. Insect-caused mortality is currently not occurring (Jahns, pers. comm.). However, in many stands, existing stocking levels exceed those recommended, based on site potential (Hopkins, 1979). Trees are under stress from competition, and may become susceptible to mortality events. Continued fire suppression will probably result in increased mortality and increased accumulation of fuels. Without prescribed burning or other fuel treatments, this will likely result in greater probability of stand-replacing fires in the future.

White Fir Mixed Conifer Zone

Historically, fire had the greatest influence in the white fir mixed conifer zone. Insects (western and mountain pine beetle, fir engraver beetle) and disease (Armillaria root rot) thinned stands and created small gaps, while windthrow was minor. The fire regime was characterized by average return intervals of 10-40 years and low intensity burns. Shorter average intervals were found at lower elevations and on dry slopes, while longer average intervals occurred on more mesic sites and upper elevations, where white fir overlaps with the red fir zone (Agee, 1993).

Trees in the white fir zone have variable resistance to fire. Ponderosa pine is the most resistant, followed by incense cedar, sugar pine, and Douglas-fir. White fir, like red fir, becomes moderately resistant with age (typically 120 years). At lower elevations and on steep south-facing slopes at higher elevations, frequent low intensity fires promoted development of ponderosa pine-dominated stands. Fires thinned out ponderosa pine stands, removed white fir before it developed resistance, and created gaps suitable for regeneration of ponderosa pine and other shade-intolerant species (Douglas-fir, sugar pine, and incense cedar). Fires were patchy and typically resulted in small clumps of reproduction of individual species (Agee, 1993). Shrubs with the ability to resprout following fires were probably favored in the openings (chinquapin, manzanita, snowbrush, snowberry), since the frequency of fires would prevent maturation of seedlings in many cases. Fuel loads were probably low. On more mesic sites, longer fire-free intervals allowed white fir to dominate stands.

Stand-replacing fires did occur in this zone, creating brush fields similar to those of the red fir zone. Stand-replacing events appear to be less frequent, however; five brush patches were located on 1940's aerial photos, averaging 30.7 acres in size and totaling .3% of the area.

Both lightning and burning by Native Americans were important ignition sources (Agee, 1993). Leiberg (1900) suggests that accidental and intentional ignitions by white settlers also occurred. For example, he reports a fire in the Cherry Creek drainage caused by hunters. Since 1960, 27 ignitions occurred in this zone at the rates of .058 lightning ignitions/1,000 acres/year and .01 human-caused ignitions/1,000 acres/year. All ignitions were suppressed. Except for a 234-acre fire in the Cherry Creek drainage in 1992, none of the fires have been greater than 1 acre in size.

Both interviews relating stories of the first settlers of the area and Leiberg (1900) described open ponderosa pine stands in the watershed area. Ponderosa pine-dominated stands were still present on the lower and drier slopes on the 1940's aerial photos. Typically, these stands had large trees and relatively open canopies (<55% canopy closure). Dense white fir understories were evident in many 1940 stands, suggesting fire suppression efforts since the turn of the century were already having an effect. Overstory removal of large pines in the 1960's and 1970's accelerated conversion to the white fir-dominated stands currently present. A sample of stand exam information from 1989-1990 shows white fir comprising an average of 80% of the basal area of lower elevation stands in the watershed area. On more mesic sites, stands were dominated by white fir in 1940 and remain so today.

The result of conversion of ponderosa pine stands to white fir stands has led to decreased tree species diversity, increased stocking levels, and forest health problems. (Potential effects on hydrology are discussed under Issue G.) This has been exacerbated by drought conditions for 6 of the past 7 years. Although white fir tolerates higher stocking levels than ponderosa pine (roughly 240 square feet of basal area verses <140 for ponderosa pine), mortality of both species is occurring.

Western and mountain pine beetles are attracted to pines that are under stress from overstocking and drought. Fir engraver beetles attack fir trees under similar conditions. While insect-caused mortality is part of the natural disturbance regime, current levels of infestation threaten all remaining pines in overstocked stands, and mortality caused by fir engraver beetles has become a stand-replacing event in some areas. A sample of 1989-1990 stand exam data indicated that 2/3 of the standing large trees (primarily ponderosa pine) per acre were dead. On average, only 1.8 large live trees per acre remained. Stands averaged 9.8 small snags per acre, an indication of the number of recently dead fir trees. Preliminary data from 1993 suggests the number of small snags has tripled in many stands since 1989-1990.

Armillaria root rot is present in the soil at all times, but generally causes mortality when trees are stressed. Fir trees are less resistant to the disease than ponderosa pine. Increased stress from overstocking, drought, soil compaction during logging, and insect infestation has accelerated the incidence of root rot in this area. Past overstory removals also promoted mortality from root rot by causing an imbalance in the amount of tree biomass supporting the underground fungal biomass, as well as removing the more resistant trees. Over 1,100 acres in the watershed area have high incidence of root rot. The heaviest infections occur north of Cherry Creek, corresponding to dry sites dominated by ponderosa pine in 1940.

Continued mortality from insects and disease will result in heavy fuel accumulations and greatly increase the probability for large, stand-replacing fires in the white fir zone. Harvest treatments and fuels treatments may lessen the effect, but it is unlikely this part of the watershed will be returned to the natural stand condition and disturbance regime for several decades.

DESIRED FUTURE CONDITION

Forest condition in the mountain hemlock zone is similar to the current condition. Forest health currently is not an issue and is unlikely to become one in the near future. Very few stands have canopy closures >70%, and many are sparse, <40%. Insect and disease-caused mortality appears to be at natural levels. Fuel loads are typically low. A fire management plan has been written for the Sky Lakes Wilderness, and directs management of fire in this zone.

Portions of the red fir zone are managed for varying interests: late successional reserve, wilderness, research natural area, and matrix lands. Individual constraints for each of these areas determine the desired future condition and limit what activities can occur. Overall, there is a reduced potential for future forest health problems and large stand-replacing events. Fuel loads have been reduced through prescribed burns or other treatments, and fuel breaks exist. Where allowed, stocking levels have been decreased by thinning of understory trees, leaving larger, more fire resistant trees. Natural fires are allowed to burn where they do not conflict with, or pose a risk to, other resource values.

The white fir mixed conifer zone is also managed for a variety of objectives: late successional reserve, wilderness, research natural area, matrix lands, and bald eagle habitat. Again, each management area has its own desired conditions and constraints. Overall, the rate of mortality from insects and disease has decreased and there is a decreased potential for stand-replacing fires. At the lower elevations and on south-facing slopes, areas previously dominated by ponderosa pine and outside the LSR, management favors the retention and recruitment of early seral species (ponderosa pine, sugar pine, Douglas-fir) over white fir. Stocking levels have been decreased with thinnings. Fuel loads have been reduced through salvage sales, prescribed burning, and other fuels treatments. Fuel breaks exist. In areas previously dominated by white fir and included in the LSR, similar, but less intensive, treatments are used, as directed in the Record of Decision for Amendments to Forest Service and Bureau of Land Management Planning Documents Within the Range of the Northern Spotted Owl/Standards and Guidelines for Management of Habitat for Late-Successional and Old-Growth Forest Related Species Within the Range of the Northern Spotted Owl (USDA Forest Service and USDI Bureau of Land Management, 1994b). This document will be referenced as the "President's Forest Plan."

B. ISSUE: Wildlife and plant habitat has been altered by timber harvest, fire suppression, and diking/draining of wetlands.

KEY QUESTIONS: How does the current condition of wildlife and plant habitat compare with what was present in 1940, before significant alteration began? The focus will be on late successional stands, canopy closure, ponderosa pine-dominated stands, and wetlands associated with Upper Klamath Lake.

ASSUMPTIONS: Information about historical habitat conditions was taken primarily from 1940's and 1950's aerial photos. "Seral stage" was defined by size/structure, which was divided into 4 categories: non-forested; early seral; mid seral; and late seral, disregarding species composition. See Appendix D for a more complete explanation of definitions and information sources used for vegetative comparisons.

DISCUSSION OF HABITAT

Stands with late seral structure covered approximately half of the watershed area in 1940. The Rock Creek drainage had the highest percentage of area in late seral stands, 57%, followed by Nannie with 53%, and Cherry with 42% (Figure 1). Fires in the Sky Lakes Basin, at the head of Nannie Creek, and on the south slope of the Cherry Creek drainage, were the primary sources of early seral habitat in the uplands. Several additional factors contributed to the lower figure for the Cherry Creek drainage. The glacial outwash fan of Cherry Creek had several acres of pole/small-sized lodgepole pine and non-forested wetlands, and the ponderosa pine stands on private land had already been harvested prior to 1940.

Late seral stands were more-or-less connected from north to south and east to west in the upland watershed area. Few isolated blocks existed, and these were bordered primarily by mid seral stands. Mid seral stands covered 29% of the Rock Creek drainage, 34% of the Nannie Creek drainage, and 30% of the Cherry Creek drainage. Together, late and mid seral stands formed the matrix of the upland watershed area. Early seral stands occurred in blocks averaging 43 acres in size (range 3.5 - 115.6). The matrix was also broken up by talus slopes, especially at the higher elevations, and, to a lesser extent, lakes. Meadows comprised only 1.4% of the area, with the largest occurring on the Cherry glacial outwash fan.

Since 1940, the amount of late seral habitat has decreased from approximately 50% to 30% of the watershed area, while the amount of mid seral habitat has remained about the same. Stands in the wilderness and Pelican Butte semi-primitive recreation area are much as they were in 1940, including the upper and mid portions of the Cherry Creek drainage. Most of the changes have occurred in the lower elevation mixed conifer stands of all three drainages, extending to the red fir zone in the Rock drainage. In these areas, late seral stands have been fragmented by timber harvesting, and early and mid seral stands now form the matrix. The amount of early seral habitat has increased from 6% to 33.5% in the Rock drainage, 10.5% to 37% in the Nannie drainage, and 12% to 34% in the Cherry drainage.

Historically, canopy closure varied with species composition, site conditions, and fire effects. Stands dominated by ponderosa pine at lower elevations and on south-facing aspects typically had canopy closures of 40-70%. Recently intensively burned stands and high elevation stands on harsh sites had more open canopies (<40%). Fir-dominated stands were typically denser with canopy closures of 55-100%. The Nannie and Cherry drainages originally had higher percentages of <40% and 40-70% canopy closure than the Rock drainage, probably due to drier slopes and more frequent fires (Figure 2). Over 30% of the Rock drainage had canopy closure greater than 70% in 1940; this was true of only 2% of the Nannie and 9% of the Cherry drainages.

Changes in canopy closure since 1940 are a result of both timber harvest and natural succession in the absence of fire. The canopies of previously ponderosa pine-dominated stands in the Nannie and Cherry drainages filled in as stands converted to white fir. Burned areas in the upper Nannie and Cherry drainages also increased in canopy cover as they reforested. These effects were not offset by harvesting. The amount of area with <40% canopy closure remained about the same, while the amount of area with 40-70% canopy closure decreased, and the amount with >70% canopy closure increased from 9 to 20% in the Cherry drainage, and 2 to 27% in the Nannie drainage. The Rock drainage originally had more fir-dominated stands with higher canopy closures than the other two drainages. Harvesting has caused an increase in acres with <40% canopy closure (24-33%) and a decrease in acres with >70% canopy closure (31-23%). More clearcutting was done recently in the Rock drainage than in the other two.

In 1940, the watershed area had approximately 6,000 acres of relatively open mixed conifer stands, dominated by ponderosa pine. A more thorough discussion of stand condition and development is described under Issue A. The combination of overstory removals and fire suppression has altered and eliminated much of this habitat type in the watershed area. Only remnant large ponderosa pine, Douglas-fir, and sugar pine trees remain in white fir-dominated stands.

Wetlands associated with the Cherry Creek glacial outwash fan and adjacent marsh have also been altered by harvesting, diking and draining, grazing, and introduction of exotic pasture plants. Approximately 700 acres of seasonally wet or wet lodgepole pine stands were present in 1940. The stands began dying in the 1960's, possibly a prolonged reaction to the change in the water table following construction of the Linkville Dam. The lodgepole pine has subsequently been logged off on almost all of the private lands; some of these areas have also been channelized for conversion to pasture. Less than 100 acres of wet lodgepole habitat are managed by the Forest. Historical accounts (Brown, 1968) describe aspen and cottonwood groves in the area. These were probably at the edge of wetlands, or mixed with conifer forests, and are not detectable on 1940 photos. It is likely that hardwoods were removed when conifer stands were harvested.

Approximately 300 acres of meadow, both carex/tufted hairgrass and seasonally wet tufted hairgrass/mix, were present along the forest edge. Many of these meadows have also been diked and drained. North of the fan lay an additional 300 acres of willow/carex wetlands, which were converted to pasture by draining and seeding with exotic species. This area was hayed in the 1950's and 1960's. The Jack Springs and Fourmile Springs allotments encompass most of the NFS land in this area. The meadows grade into surrounding marsh (approximately 1,400 acres). The marsh has been altered by construction of an extensive canal system (Fourmile and Sevenmile). All of the wetland areas have been grazed since the turn of the century by cattle, and at one time, sheep.

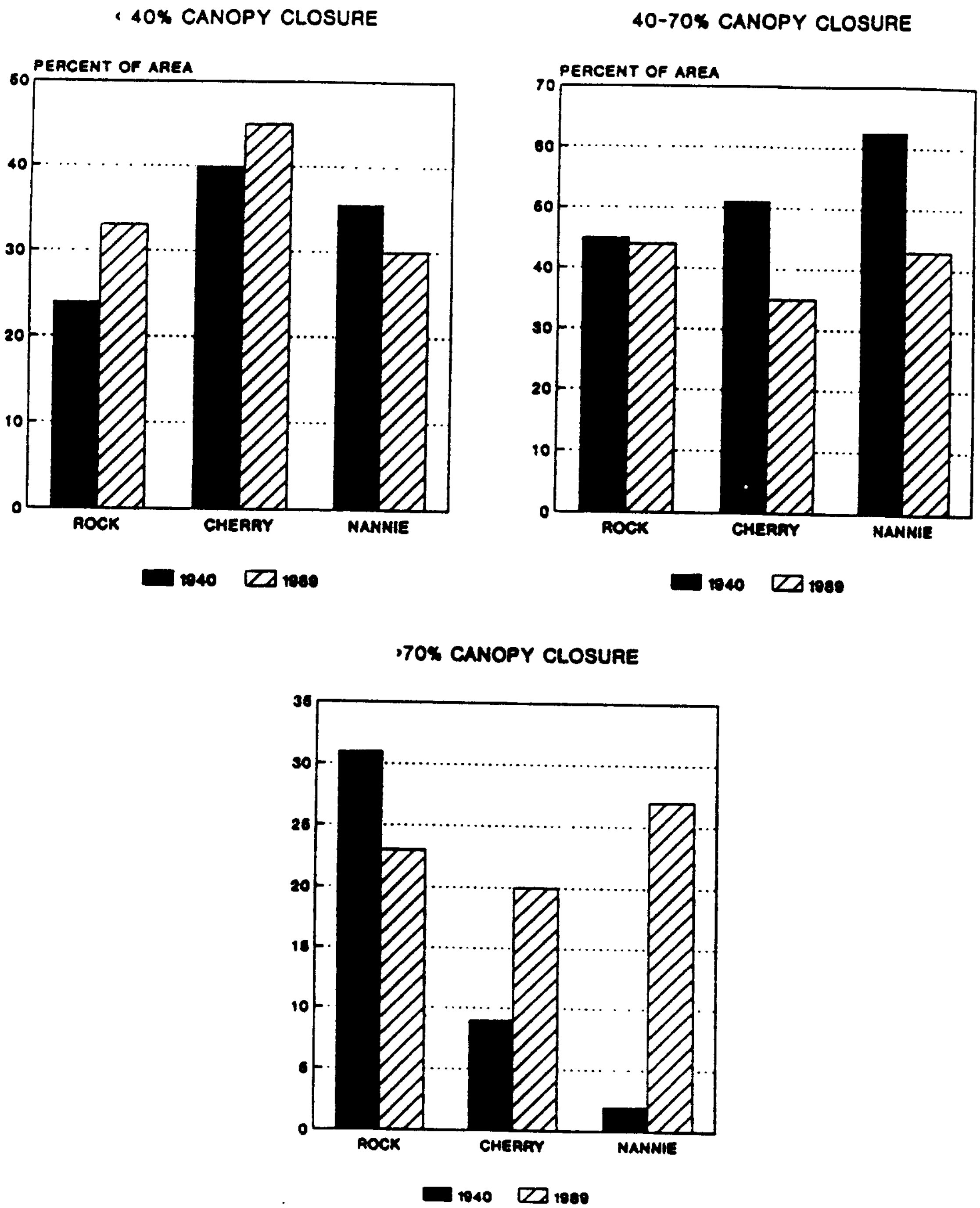


FIGURE 2. CANOPY CLOSURE

EFFECTS ON WILDLIFE SPECIES

Over 290 wildlife species documented, or with potential habitat in the watershed area are listed in Appendix B. It is impossible to determine what species were originally present and how each has been affected by management activities in the past 50 years. However, generalizations based on habitat changes can be made.

Fifty-six species are associated with late seral habitats or mid-to-late seral habitats with >55% canopy closure (Appendix B). An additional 20 species use large trees in open stands or stands with variable canopy cover. Eleven of these species have special management consideration because of Federal listing, state listing, or Regional sensitive status, and six are recognized as management indicators on the Forest.

As noted above, the total area of stands with late seral structure has been reduced, and late seral stands at the lower elevations in the Nannie and Cherry drainages and mid-to-lower elevations in the Rock drainage have been fragmented. Fragmentation can affect species by limiting their dispersal, decreasing local population size, and decreasing the suitability of remaining habitat by causing edge effects. The effects of fragmentation have probably been more pronounced in the Rock drainage where canopy closure was originally higher and more clearcutting has been done recently. A landscape analysis of late seral habitat will be done following this analysis and reported in the up-coming Nannie/Rock environmental analysis document.

Species with large home ranges that use a mix of different habitat types probably have been little affected by the loss of late seral stands, although hunting pressure or increased human access and disturbance could be important. The elk herd in the Cherry drainage is currently increasing. The status of the bear population is unknown. There are no recent records for North American Lynx.

Species that require interior habitats or large blocks of late seral habitats such as spotted owls and goshawks, may have been more affected by the decrease in late seral habitat; this will be discussed in another document, as described above. Amphibians and small mammals with a limited ability to migrate may also have declined, although they would be able to maintain a higher population density in remaining small blocks than larger species (Lehmkuhl and Ruggiero, 1991).

It should be noted that large blocks of Shasta red fir and white fir mixed conifer late seral stands remain intact in the upper and mid portions of the Cherry Creek drainage. This is probably some of the most important wildlife habitat in the area because of the perennial water source, diversity of habitats (small meadows, springs, talus, etc.), and lack of roads.

Appendix B also lists eighteen species which use open ponderosa pine-dominated stands or prefer to breed/feed in the ponderosa pine, Douglas-fir, sugar pine component of white fir-dominated stands. Many of these are primary or secondary cavity nesters, and raptors. The effect of management activities on the habitat of these species in the watershed area has been significant. The number of large ponderosa pine, Douglas-fir, and sugar pine trees has declined dramatically since 1940. In many areas, existing large trees of these species are experiencing high mortality, and natural recruitment is low (see Issue A).

Habitat for 98 wildlife species is present, or originally may have been present, in the lower elevation wetlands of the watershed area. Alteration of these areas has been substantial. The change in hydrology caused by diking, draining, and building of canals has altered water flow and possibly water temperature and quality. Species such as the spotted frog may have been affected (Hayes, 1993). Changes in vegetation structure and composition caused by conversion of wetlands to pasture and decades of grazing has altered habitat for small mammals and wetland birds such as the yellow rail (Stern, 1994). Willow thickets have also been lost through wetland conversion, limiting habitat for species such as the willow flycatcher and common yellow throat. Logging has decreased the amount of habitat for birds that prefer to nest or feed in forested wetlands or deciduous stands. The presence of human dwellings and fields may have encouraged the invasion of exotic species, such as European starlings, brown-headed cowbirds, house sparrows, house mice, Norway rats, and cats, which compete with, prey upon, or parasitize the nests of native species.

EFFECTS ON PLANT SPECIES

Appendix C lists nearly 400 vascular plants and 80 species of fungi documented or likely to occur in the watershed area. Forty-one species are listed as being associated with late seral habitats in the SAT (Thomas, Raphael, Meslow, et al., 1993) and FEMAT (Thomas, Raphael, Anthony, et al., 1993) reports. Personal observation (Malaby, 1990-1994) suggests many of the vascular plant species on the list occur in a variety of mid-to-late seral stands and respond more to light and moisture gradients than stand structure. A majority of the species are typically found in mesic or riparian stands with 55-70% canopy closure. Some also occur along the edges of wet meadows and lakes and in mesic openings (e.g. big huckleberry (Vaccinium membranaceum) and solomon's seal (Smilacina stellata). None are common in open early seral stands, cutover stands, or dense pole/small-sized stands with 100% canopy closure. Little information is currently available about fungi on the District. Bryophytes and lichens have not been studied.

Management activities during the past 50 years have probably had similar effects on plant and fungi species associated with late seral habitats as on late seral wildlife species: a reduction in the total amount of suitable habitat and fragmentation. Partially cut stands that have retained a mid-to-late seral structure after logging have less available habitat for these species than originally, due to soil compaction and disturbance. Compacted skid trails and landings are slow to revegetate. Canopy opening and soil disturbance promote establishment of brush or weedy species. As seen on the list, several non-native species have been introduced to the area. Bull thistle (Cirsium vulgare) and mullein (Verbascum thapsus) are often the most common ground cover for the first 5 years after canopy opening and soil disturbance. The noxious weed St. Johnswort (Hypericum perforatum) is slowly spreading along roadsides and landings in the watershed area. Knapweed (Centaurea maculata) and Canada thistle (Cirsium arvense) are currently present in small amounts.

Two of the late seral species are rare on the District. Pacific yew (Taxus brevifolia) is at the eastern edge of its range on the District and occurs near the Cascade crest in the Lake of the Woods area, and in disjunct populations in individual drainages, including the Cherry drainage. Mt. Mazama collomia (Collomia mazama), endemic to the southern Oregon Cascades, is a candidate species for federal listing (C2). A challenge costshare project beginning in 1994 will investigate its habitat requirements.

Thirty-eight species of plants listed in Appendix C are most likely to occur in drier habitats with partially open canopies, typical of ponderosa pine-dominated stands. Fire suppression, coupled with overstory removals, has converted pine stands with late seral structure to early seral fir stands, with increased canopy closure and depauperate ground cover. Where canopies remain open from logging, the lack of fire has probably caused a shift in the composition of herbaceous species. Soil disturbance from logging has also promoted growth of brush patches and weedy species in many stands.

Over 100 species of plants are associated with low elevation wetlands in the watershed area. The greatest diversity is found in the vernally wet meadows, remaining remnants of lodgepole pine swamps, and ecotonal areas. Native species have been greatly affected in this area. Soil disturbance, compaction, and selection by livestock appears to have caused a shift to dominance of weedy and less palatable species on heavily-grazed sites. Remaining willows are mostly decadent and have "mushroom" shapes indicative of repeated grazing. A number of introduced species are present. Kentucky bluegrass (Poa pratensis) has become naturalized and is now the dominant component of moist meadows. Meadow foxtail (Aplopecurus pratensis) and reed canary grass (Phalaris arundinaceae) are common on wetter sites. The opposing effects of installation of the Linkville Dam and local diking and draining are difficult to interpret. Draining of wet areas and irrigation of dry areas has probably led to more homogenized habitats and decreased microhabitat diversity. It is also likely that the number of acres which have standing water throughout the summer has been reduced.

A small population of sticky catchfly (Silene nuda ssp. insectivora), a Region 6 sensitive species, is located in the lower wetland area. The species probably once occurred more extensively in moist meadows on the west side of Klamath Lake. Currently, only two known populations occur on the Klamath District.

DESIRED FUTURE CONDITION

Inside the Late Seral Reserve (primarily in the Rock Creek drainage), habitat conditions are returning to pre-timber harvest conditions. Regeneration stands are fully stocked, and overstocked stands have been thinned under the guidelines of the President's Forest Plan to promote development of late seral habitat. Existing large ponderosa pine, Douglas-fir, and sugar pine trees and snags are retained to the extent possible. Outside of the LSR, and in bald eagle management areas, large ponderosa pine, Douglas-fir, and sugar pine trees are retained, and regeneration of these species is occurring through the use of timber harvest and prescribed fire. The occurrence of new soil disturbance has been minimized during logging operations by the use of designated skid trails, moisture level restrictions, and/or over-the-snow logging. Existing noxious weeds have been controlled. Lodgepole pine swamp habitats on NFS lands are maintained in their current condition. Moist meadows on NFS lands have been rehabilitated by subsoiling and seeding with native species, including sticky catchfly.

C. ISSUE: Subalpine lakes have been impacted by fish stocking and recreation.

KEY QUESTIONS: What are the potential impacts of fish stocking?

Has camping near lakes degraded water quality?

DISCUSSION

Fish stocking in subalpine lakes of the Sky Lakes Wilderness began as early as 1947. Brook trout, rainbow trout, and cutthroat trout have been stocked in varying amounts in almost all of the larger lakes (Deep, Deer, Donna, Elizabeth, Heavenly Twins, Isherwood, Margurette, Notasha, Puck, Snow, Sonya, Trapper, Wind, Wizzard).

Possible impacts from fish stocking in previously fish-less lakes are beginning to be investigated in the Pacific Northwest, prompted by recently discovered widespread declines in amphibian populations (e.g. Hayes and Jennings, 1986). In addition to loss of amphibians, discussions in the literature focus on changes in the lake trophic state through introduction of nutrients, or predation on zooplankton, with a cascading effect on phytoplankton.

Work by Liss and Larson (1992; pers. comm.) in the North Cascades National Park has found fewer long-toed salamanders and a decrease in large zooplankton (and subsequent increase in small sized zooplankton) in lakes with high densities of stocked fish, particularly in lakes where fish are able to reproduce and maintain populations with different size classes. Salamanders also behave differently in stocked lakes, spending more time hidden under litter and woody debris. This may impact their ability to forage (Hoffman, pers. comm.). In other papers, Bradford (1989) compared stocked and unstocked high elevation lakes in the Sierra Nevada and found frogs absent where fish were present. Hayes and Jennings (1986) also cite studies describing impacts on frogs.

In the watershed area, information is limited. A study at Lake Notasha (Eilers, 1994) located fewer amphibian species than previously reported by Marangio (1978). However, Eilers (1994) attributed the loss to drought rather than fish stocking, since stocking began several years prior to 1978. Eilers' surveys may also have been less intensive.

Fish stocking was halted in Lake Notasha in 1992, following an agreement between the Oregon Department of Fish and Wildlife and Oregon Natural Resources Council. Eilers noted a temporary increase in a large zooplankton species (Diaptomus kenai) in 1993, sufficient to alter water clarity, which may have been related to cessation of fish stocking. Phytoplankton populations in Lake Notasha did not appear to respond to the change. There was no indication of a change in nitrogen or phosphorus levels in 1993. The water chemistry of Lake Notasha correlated well with input from precipitation. Nearby lakes were also sampled and either had water chemistry similar to precipitation or runoff, indicating a lack of significant nutrient input from another source, such as fish stocking.

In conclusion, there is currently no evidence that fish stocking is impacting the water chemistry of subalpine lakes in the watershed area. Shifts in zooplankton communities may be occurring. Based on findings of other studies, the presence of fish may be affecting some amphibian species. Amphibian surveys will be conducted in the watershed area in 1994 and may yield additional information. However, because all sizable lakes have been stocked, comparison of similar stocked and unstocked lakes will be limited.

Recreationists often camp near the shores of the larger lakes in the watershed area creating denuded, compacted sites and social trails. The lakes studied by Eilers - Notasha, Heavenly Twins, Isherwood - are some of the most popular among campers. Although Eilers' findings indicate current recreation use does not appear to be causing detectable pollution or sedimentation, he cautioned that increased use and trail runoff should be avoided. Because current levels of nitrogen and phosphorus are low, even small additional inputs could have a significant impact. He notes that manure from one horse (presumably one pile) has the potential to add more nutrients to lake water than a cubic meter of soil from the area. The District is attempting to close and rehabilitate campsites within 100' of wilderness lakes. Efforts have so far produced mixed results. The number of people visiting the wilderness may increase slightly in the next few years, due to population growth in the Rogue Valley (Mitchell, pers. comm.), or may increase dramatically if a recently proposed resort and ski hill are built in the area. Increased visitor use could hamper efforts to rehabilitate lakeshores.

DESIRED FUTURE CONDITION

The issue of fish stocking has been more thoroughly investigated, amphibian surveys have been completed, and information is available to assess whether stocking should continue in all of the traditionally stocked lakes.

Camping within 100' of lakeshores is reduced or eliminated, and existing campsites are beginning to regain vegetative cover and duff. Trails and waterbars have been improved to prevent erosion and runoff into the lakes.

D. ISSUE: Native fish populations have been impacted by introduction of exotic fish and alteration of habitat.

KEY QUESTIONS: Has introduction of exotic species contributed to the decline of native stocks?

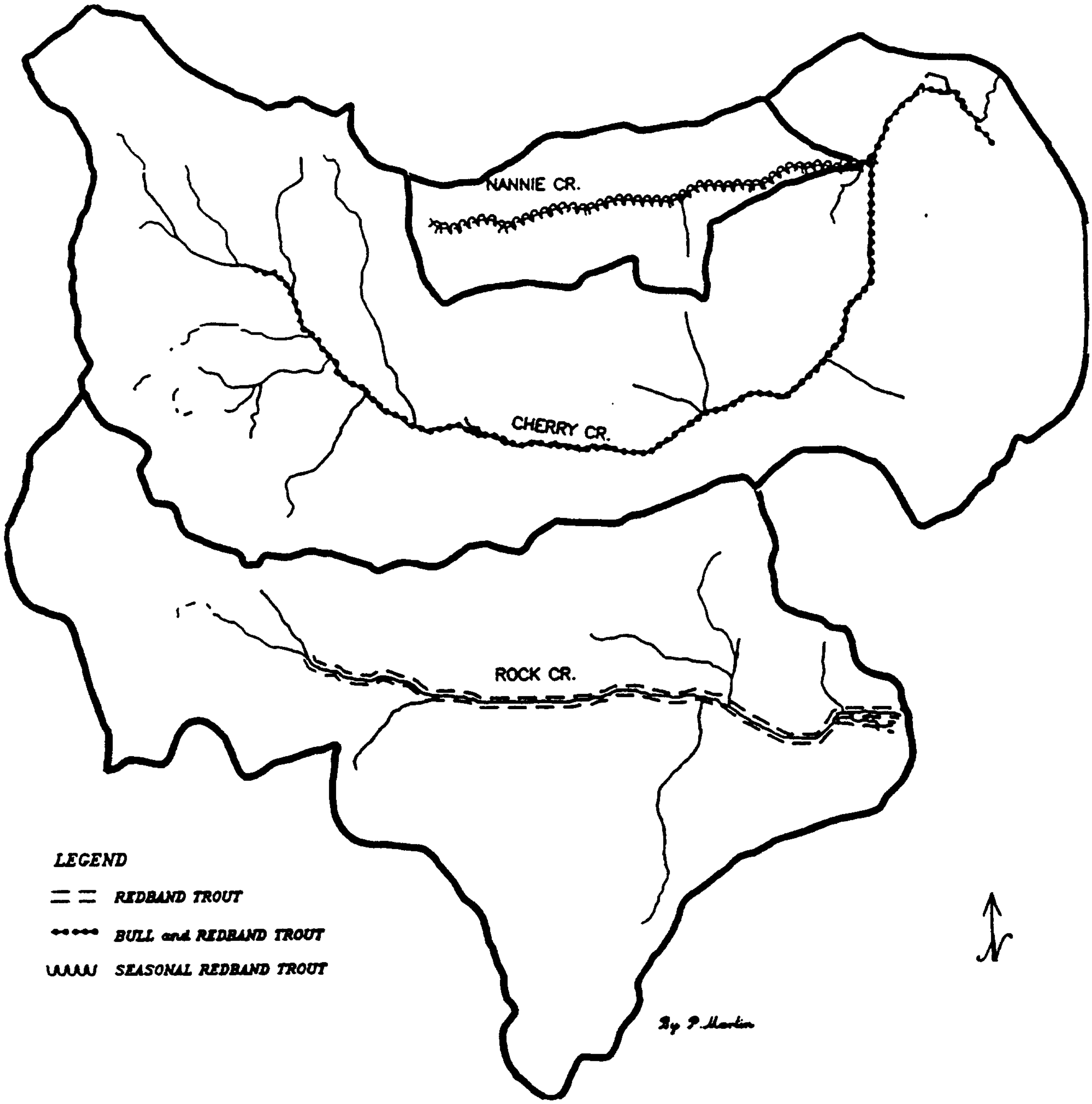
Has fish habitat been altered, and has alteration contributed to a decline of native fish populations?

ASSUMPTIONS: Historically, adfluvial (migrating from streams to lakes) populations of bull and redband trout coexisted in Cherry Creek. Nannie Creek is an intermittent system that was not utilized by bull trout, but may have been utilized by redband trout for seasonal foraging. Rock Creek historically provided habitat for redband trout. Currently Rock Creek connects with Upper Klamath Lake briefly in the spring. Because this connection is not believed to have been significantly altered (see Issue G), it is unlikely that bull trout originally inhabited Rock Creek.

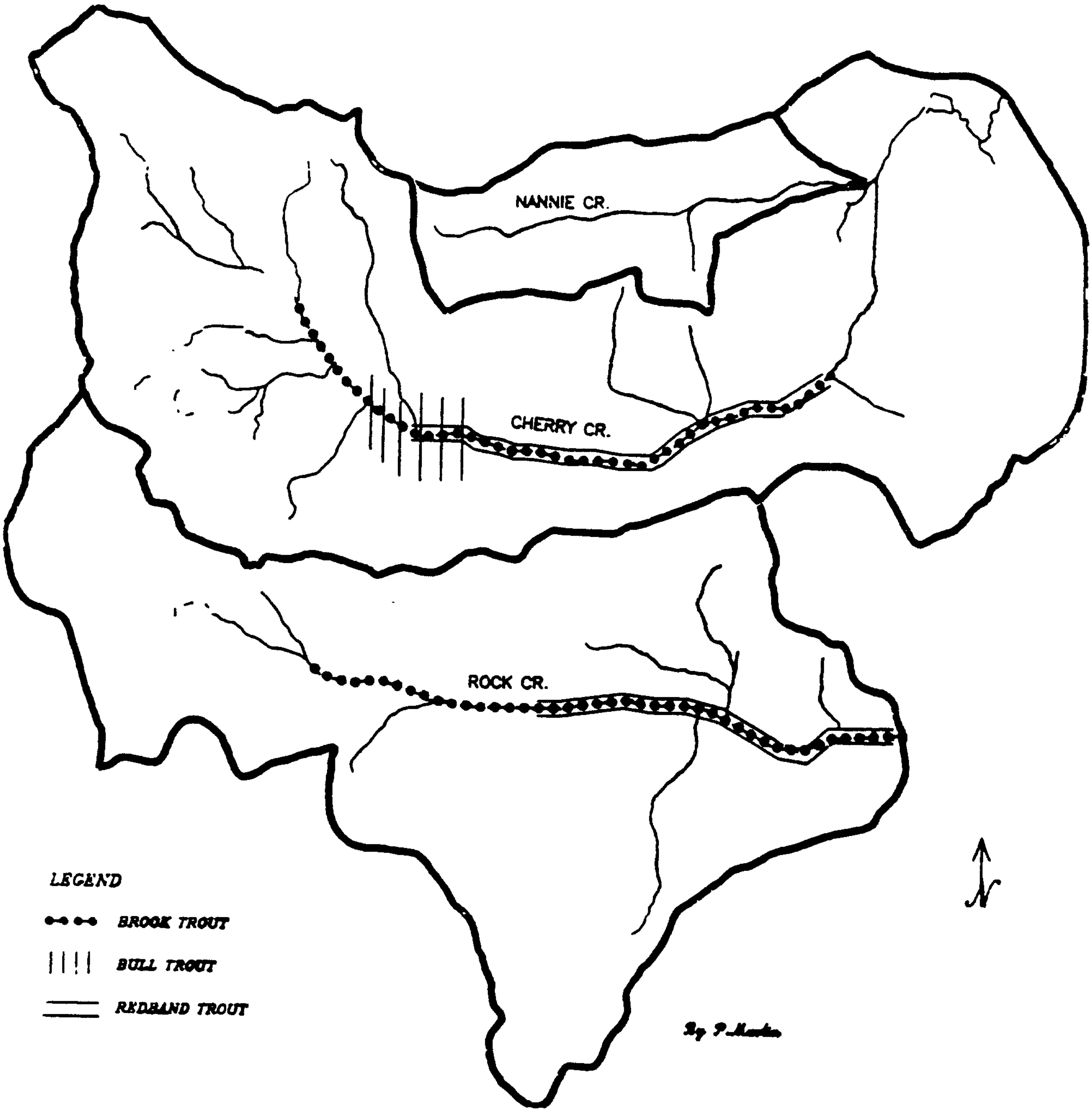
DISCUSSION

Historically, fish populations within the watershed area consisted of adfluvial bull trout (Salvelinus confluentus) and redband trout (Onchorynchus mykiss). These species evolved together in the Klamath Basin, coexisting in the same systems. For the most part, these two species utilized different portions of the microhabitat within a stream: bull trout are fall spawners and prefer pool habitat, while redband trout are spring spawners and prefer faster moving water (Dambacher et al., 1992; Fausch, 1988). There is some overlap between bull trout and redband trout in that they share rearing habitat, and juveniles use some of the same forage base. As adults, however, adfluvial bull trout were a piscivorous species that shared little of the food habits of other salmonids (Willamette National Forest, 1989). Historically, bull and redband trout are known to have existed throughout Cherry Creek (Thomas, 1992) (see Map 6). No known records exist for the native fish populations within the Rock and Nannie Creek systems prior to fish stocking.

The Oregon Fish Commission initiated a stocking program in the Rock and Cherry Creek watersheds in the 1930's. Fingerling introductions of brook trout (Salvelinus fontinalus) were made sporadically until the late 1950's, when stocking of smaller streams in the Klamath Basin was discontinued (John Fortune, pers. comm.). The concern with an introduced species is that they can disrupt the natural allocation of resources, displacing natives through competition for food, cover, and space. Redband and brook trout have an overlap in forage base and in rearing habitat for young fry. Because bull trout in Cherry Creek are no longer adfluvial (and therefore, not as likely to be piscivorous), brook and bull trout also utilize the same forage base (Willamette National Forest, 1989) and microhabitat (Dambacher et al., 1992). Both species prefer pool habitat and feed primarily on aquatic insects; however, brook trout appear to dominate the most desirable positions within the pools. This may lead to the exclusion of bull trout from their preferred habitat, possibly causing them to suffer a diminished ability to feed and grow (Dambacher et al., 1992). (See Map 7).



MAP 6. HISTORICAL FISH DISTRIBUTION



MAP 7. PRESENT FISH DISTRIBUTION

Introduced brook trout pose an especially serious threat to bull trout populations (Ratliff and Howell, 1992; Markle, 1992). These species belong to the same genus, spawn at the same time, and are able to hybridize. However, life history differences favor brook trout: they reach sexual maturity at a younger age and are more prolific than bull trout. This leads to the displacement of bull trout (Ratliff and Howell, 1992). Hybridization often results in sterile offspring (Howell, 1993), thus leading to the gradual depletion of the bull trout gene pool and a trend toward extinction.

Along with the introduction of brook trout, alteration of habitat is also contributing to the decline of native fish populations. Spatial and temporal connectivity within and between watersheds is necessary for maintaining aquatic and riparian ecosystem functions (Thomas, Raphael, and Meslow et al., 1993).

Aerial photos indicate that all three systems originally had at least an intermittent connection to Upper Klamath Lake, with Cherry Creek most likely connecting year-round. This connectivity to Klamath Lake has been lost in Nannie and Cherry Creek. Nannie Creek's connection has been lost through channelization. Several roads crossing this system have also created barriers to fish passage. This has resulted in a loss of seasonal forage habitat for fish that are now unable to reach Nannie Creek. Cherry Creek's original connection has been lost through de-watering of the channel by diversion since the early 1900's. The man-made channels that remove water from the original channel are used for irrigation and a gravel mining operation. After being routed through a series of canals, this water eventually drains into the Fourmile Canal, which connects with Upper Klamath Lake. These changes have impacted native fish populations by changing life history patterns, reducing genetic interchange, and increasing interspecific competition.

The first impact loss of connectivity has had on native fish is a change in life history patterns from adfluvial (fish that migrate between streams and lakes) to resident (fish that stay in streams). Historically, adfluvial adult bull trout moved upstream to spawn in the fall. Resulting juveniles reared for about two years in slow-moving waters of the stream. Juveniles migrated to the lake in their third year, where they became piscivorous and grew more rapidly. They matured at age 5 or 6 and returned to streams to spawn (Ratliff and Howell, 1992; Pratt, 1992). Bull trout have lost this life history with the disconnection to Upper Klamath Lake (Dambacher et al., 1992). Remaining bull trout are in isolated populations that now have a resident life history. Resident bull trout mature at an earlier age, are reduced in size, have a lower fecundity than adfluvial populations, and do not become pisciovorous as quickly (Howell, 1993; Willamette National Forest, 1989). Howell (1993) states that loss of this adfluvial life history may be an important factor in the decline of bull trout because there is a loss of habitat capable of producing large adults. Loss of large adults results in a decline in reproductive capacity because fecundity increases with size. Large adfluvial bull trout are also probably less likely to hybridize with smaller brook trout (Ratliff and Howell, 1992), which would limit the chance of gene pool deletion driving these populations to extinction.

The second impact disconnection creates is isolation of breeding populations of native fish. Isolated populations face an increased risk of extinction because of chance environmental events. They may also suffer from a lack of genetic exchange that can lead to inbreeding depression and lower the productivity of a population (Howell, 1993; Ratliff and Howell, 1992).

Finally, interspecific competition can increase with the loss of connectivity. With historic adfluvial populations, most adults left the system and did not compete with juveniles for food or space. When these populations were converted to residents, competition increased because adults will hold the most desirable locations within the microhabitat. Because resident fish grow slower and do not become piscivorous as quickly, adults and juveniles compete for the same forage base.

In conclusion, native fish populations have been impacted by alteration of habitat and introduction of brook trout. As a result, the composition and distribution of fish species in Rock, Cherry, and Nannie Creeks has changed. Nannie Creek is no longer a fish-bearing system during spring run off. Bull trout populations in Cherry Creek have been restricted to upper reaches, where their status is rated as being at high risk of extinction (Ratliff and Howell 1992). Redband are restricted to lower and middle reaches, and brook trout are found throughout the Rock and Cherry systems. Currently, both the native bull and redband trout populations are listed as sensitive on the Regional Forester's List and are listed as category 2 species by the USFWS under the Federal Endangered Species Act.

DESIRED FUTURE CONDITION

In Rock and Cherry Creeks, fish populations have returned to pre-fish stocking conditions. Native fish habitat has been expanded as bull and redband trout populations are retained and brook trout are removed from the systems. Fish screens have been placed on the Cherry Creek diversions to prevent loss of native fish into downstream ditches. In-stream flows are retained in Cherry Creek, and the year-round connection between Cherry Creek and Upper Klamath Lake has been restored. The adfluvial component of native fish life history is re-established as the connection is restored.

E. ISSUE: Fish habitat has been impacted by previous land management activities in Rock, Cherry, and Nannie Creeks.

KEY QUESTIONS: What is the current condition of fish habitat? How have past management activities impacted fish habitat?

ASSUMPTIONS: Water quality is not a limiting factor of fish habitat in these streams on NFS lands.

DISCUSSION

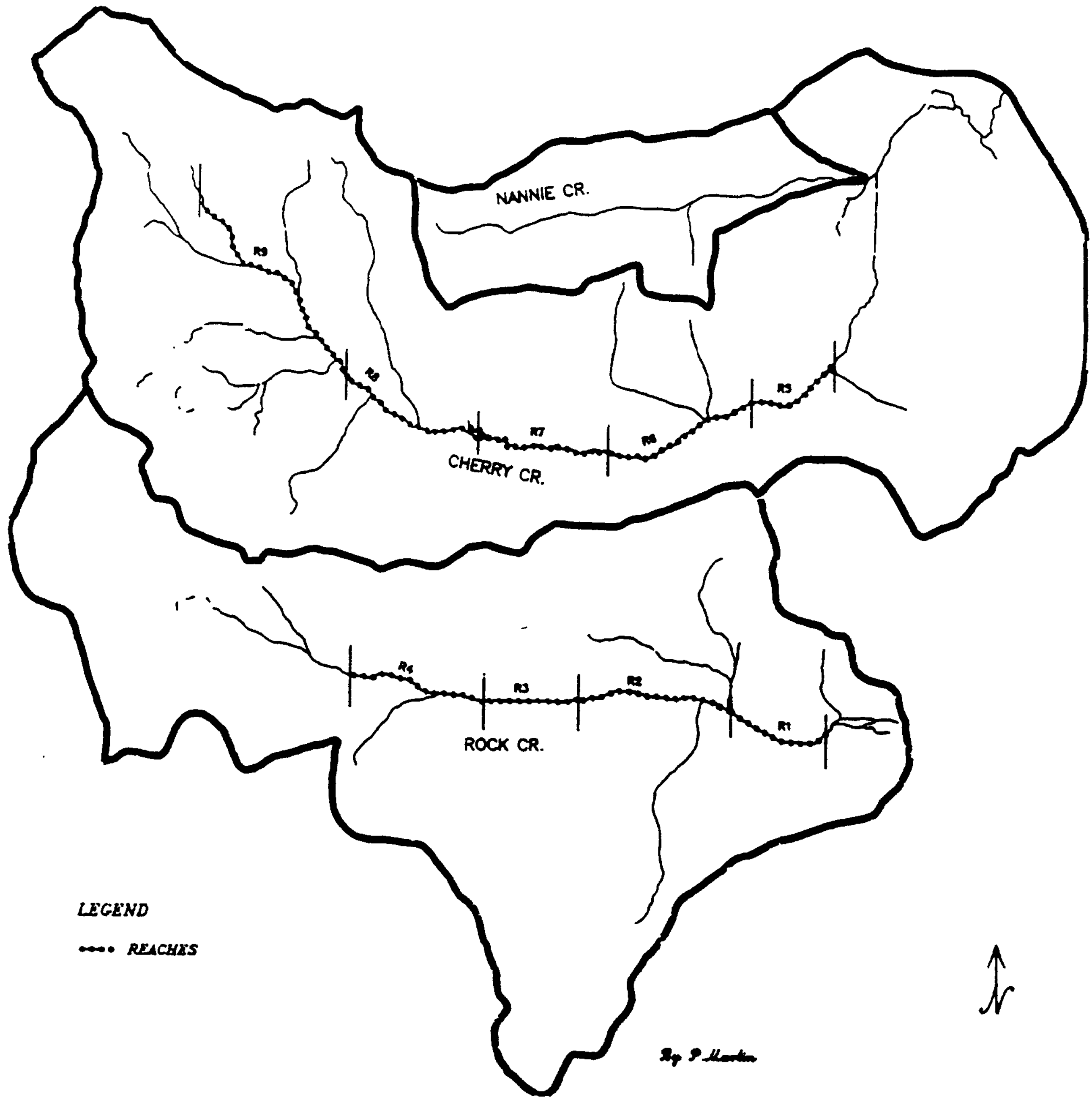
Rock Creek

Rock Creek is a third order stream, best characterized as a step-pool system. Headwaters originate in the Sky Lakes Wilderness, where the system flows approximately 2.5 miles through a narrow U-shaped valley. For the last 4.0 miles, the valley narrows to a V-shaped form, and the gradient increases. Middle reaches flow year-round and provide habitat for redband and brook trout. Rock Creek connects with Crystal Creek and Upper Klamath Lake on an intermittent basis.

A 1990 stream survey of Rock Creek indicates that, in its current condition, the stream provides marginal fish habitat overall. Rock Creek has a low habitat complexity and is dominated by shallow riffles. Few primary pools exist. Available pool habitat is predominately small pocket pools created by the geology of this step-pool system. Spawning substrates are sporadically located throughout this boulder-dominated system, but rarely accumulate in quantities large enough to qualify as quality spawning habitat. Hiding cover is limited in the lower half of the creek, and is provided predominately by boulders and turbulence. Areas of reduced flow velocities that are ideal for juvenile rearing habitat are limited throughout the system, with most suitable rearing habitat occurring in reaches three and four. Large woody material in the lower two reaches (Map 8) is extremely low, and does not meet the Regional recommendation of 20 pieces/mile. Future recruitment from side slopes is also limited in these two reaches.

Although there have been several timber sales in the watershed, a sanitation sale which took place in 1971 has had the greatest impacts on Rock Creek. This timber sale occurred along an approximately two-mile-long section of Rock Creek and was designed to remove instream large woody debris and adjacent large trees in the riparian zone. Trees were harvested on both sides of the bank, and skidded through the creek. Associated with this timber sale are numerous roads and skid trails that parallel the creek throughout these lower two reaches. Large berms of boulders, trees, and soil were placed along portions of the creek to protect road side slopes from the creek.

Penn Creek, an intermittent stream that is a major tributary to Rock Creek, has been altered. Its ability to transport water, sediments, and organic materials to Rock Creek has been eliminated due to past management activities. Roads, skid trails, and debris piles have altered the creek to such a degree that a defined channel is no longer identifiable in places.



MAP 8. STREAM REACHES

A correlation between quality of habitat and management activities is apparent: quality of fish habitat is poorest in reach one and most of reach two, and improves in upper reaches three and four. The upper reaches of the stream are in, and adjacent to, the wilderness and provide the best habitat in terms of complexity, large woody debris, and spawning habitat. Lower reaches, where habitat is the poorest, are associated with the greatest intensity of land management activities.

Fish habitat has been adversely impacted by activities that have eliminated or altered the natural functions of this system and its main tributary. The most significant impact has been the removal of instream wood and large trees in the riparian zone. Large woody material has a multi-faceted function in a steep stream such as Rock Creek: wood creates pools, provides fish cover, forms substrate for invertebrates, traps gravel for spawning and invertebrate production, and holds organic matter. As described earlier, suitable spawning substrates are very sparse throughout most of Rock Creek. Spawning material is available in the system, but it is transported quickly through the creek. Although rapid transportation of sediments is a process that occurs naturally in Rock Creek, woody material could serve to increase the retention time of these gravels in the system. The same holds true for pools and hiding cover. Large wood can create plunge, dammed, or lateral-scour pools that offer resting and deep water hiding habitat for fish. Because wood has been removed, pool quality and quantity have been reduced in Rock Creek. Skid trails through the creek have created exposed raw banks that are susceptible to raveling. This raveling limits the success of vegetative growth on banks that could provide hanging vegetation for fish. Removal of wood and destruction of hanging vegetation has reduced hiding cover that is crucial for security from predators and competitors for fish in a shallow stream such as Rock Creek. Berms of debris piled along the creek to protect roads limit the channel's ability to meander. This results in a loss of important fish habitat features associated with natural meanders and pool-riffle patterns.

The potential for recruitment of large wood into the stream in the near future (next 30 years) is limited due to past management activities. Two factors account for this: (1) large trees were harvested in the riparian zone, and (2) roads and skid trails that parallel the stream have created compacted areas that limit the regrowth potential of trees in the riparian zone. Forest Road 3419-060, which is within 50' of the creek, eliminates woody debris recruitment from the hillslope above for approximately one mile in reach one.

Penn Creek, the main tributary to Rock Creek, is important to Rock Creek's sediment and organic budget. Field investigations indicate that in places, Penn Creek is transporting sediments suitable for spawning. Due to past management activities that have altered the channel form, it is highly unlikely that these sediments get delivered to Rock Creek. Return of this function could deliver badly needed gravels to the lower reaches of Rock Creek.

Cherry Creek

Cherry Creek is a third order stream, flowing through a U-shaped valley with a moderate gradient. Two-thirds of this creek lie within the Sky Lakes Wilderness. This perennial creek provides habitat for redband, bull, and brook trout. Within the lowest reach on NFS, a diversion routes most of the water from Cherry Creek into privately owned Fourmile Canal, an irrigation ditch that drains into Upper Klamath Lake.

A 1990 stream survey of Cherry Creek indicated that this system provides only fair habitat for fish. However, confidence in this survey is low, and preliminary field investigations indicate that Cherry Creek provides good habitat conditions for fish in the five reaches above the diversion. The upper three reaches of Cherry Creek (reaches 7-9) lie within the Sky Lakes Wilderness, and are relatively unaffected by land management activities. Within these wilderness reaches, fish habitat is in good-to-excellent condition: large woody debris is abundant, available hiding cover is excellent, substrate suitable for spawning is ample, and future large wood recruitment is at a natural potential. Beaver activity in reach seven has created large, deep pools and side channels that provide rearing/resting habitat for juvenile and adult fish. Within the other two reaches above the diversion (reaches 5-6), instream woody material and effective hiding cover for fish are limiting. Substrates suitable for spawning are available in reach six. Quality and quantity of pool habitat is not known for any of the reaches above the diversion. Pool habitat data collected during the stream survey needs to be verified, because many pools were lumped together or included in other habitat types, and may not have been adequately reflected in the stream survey. The survey indicates that pool habitat is limited throughout the system. This conflicts with recent field investigation which indicated that pool habitat is adequate. No stream surveys have been conducted on Cherry Creek below the diversion. Field investigation shows that this lower portion of the system provides minimal habitat for fish. A description of this area can be found under Issue F.

Most of the habitat above the diversion canal has been only moderately impacted by past land management activities. These impacts have occurred predominately in reach 5, where a salvage sale designed to remove large in-stream wood took place. Also within reach 5 is a headgate to a diversion that takes most of the flows from this system. These activities have affected the fishery in three ways: a loss of habitat complexity, a loss of fish, and a reduction in length of stream available to fish. Removal of large wood has reduced the structural and habitat complexity within reach 5. The headgate to the diversion is screenless. Large fish are frequently seen resting in a deep pool adjacent to the headgate; they are most likely pulled down into the diversion canal when the headgate is opened. Overall stream length is reduced when the diversion de-waters the two other channels of Cherry Creek.

Quantity of large woody debris and hiding cover for fish was identified as low during the stream survey in two reaches (5 and 6) above the diversion. In-stream salvaging of large wood is no doubt partly responsible for the low quantity of wood. However, quantity of wood is also low in areas that have not been salvaged. Therefore, limited large woody debris in these reaches appears to also be a function of natural processes occurring in the system. Hiding cover for fish was also identified as low in reaches 5 and 6, where the dominant form of hiding cover is provided by substrate. Due to its size, the majority of this substrate provides effective hiding cover for only small fish. Fish hiding cover may be limited, due to the lack of wood, which can create a variety of hiding cover habitats. In a system like Cherry Creek, where water quality and quantity are not limiting, cover can be positively correlated to fish density and biomass. As hiding cover becomes limiting, some fish are displaced and are susceptible to predation. Because fish abundance can be limited in low cover conditions, quality and quantity of hiding cover should be investigated in these reaches as a potential limiting factor to fish populations.

Manipulation of Cherry Creek at the point of the diversion and below has altered the original channels to such an extent that habitat for fish is minimal. Along with the removal of instream wood, the system has been channelized and is routed through a series of irrigation canals before entering Upper Klamath Lake. Habitat complexity has been almost eliminated in reaches below the diversion.

Nannie Creek

Nannie Creek is a second order stream with an intermittent flow. An approximately 1/2-mile section maintains perennial flow. An electrofishing survey conducted in 1993 indicated that the perennial section of Nannie Creek is not fish bearing. A stream survey has not been conducted on this system.

Although historical duration of spring flows is not known, there is a potential that spawning fish migrated into Nannie Creek and utilized this system during high spring flows. Historically, this system also influenced downstream fish habitat through its transportation of sediments, wood, and organics to the north fork of Cherry Creek and Fourmile Creek.

Past management activities, on and off NFS lands, have eliminated the ability of this system to provide fish habitat. It is unlikely that fish are able to migrate into Nannie Creek from downstream habitat due to numerous dikes and canals. In Nannie Creek itself, several culverts also limit fish passage. Likewise, the system's contribution to downstream fish habitat is now insignificant because water from Nannie Creek is routed through the Fourmile Canal and then directed through a series of dikes before entering Upper Klamath Lake.

DESIRED FUTURE CONDITION

There is adequate habitat for viable populations of native fish. Water quality continues to meet State standards. Large woody debris meets the minimal Regional recommendation of at least 20 pieces per mile. Pool-to-riffle ratio meets the Regional recommendation of 40:60. The riparian zones are protected and maintained to provide large tree recruitment into the streams. Fish passage is maintained in all fish-bearing systems. The potential for large wood recruitment and channel migration has improved in Rock Creek, as roads within 0.25 miles of the stream channel are obliterated.

F. ISSUE: Channel condition has degraded.

KEY QUESTION: Have timber harvesting, road building, and stream diversion activities altered channel dynamics?

DISCUSSION

Rock Creek

Nearly the entire stream network is dominated by processes characteristic of the A and B channel types, according to the Rosgen classification system. The stream channel is entrenched to moderately entrenched, sinuosity is low, width/depth ratio is moderate (>12), and gradients are high. Energy dissipation during high water occurs in overflow channels rather than floodplains.

Stream density is low, reflecting rapid infiltration rates. Tributaries are intermittent; thus, the potential for sediment routing into the mainstem is low. As a result, stream bank and bottom sediments in Rock Creek are introduced predominately from colluvial processes (accumulation of soil material from gravitational action). A slight deviation occurs in Sections 31 and 36, where the stream gradient decreases. With the decrease in gradient, sinuosity is present, eroding banks and forming point bars. A markedly different process occurs in the lower reach, below the slopes of the Cascades. Sediment transported by the stream is deposited, building an alluvial fan. Several channels are identifiable in this area. The result is flow distribution among multiple channels. After spring runoff, streamflow subsides into previously-laid deposits and rarely reaches Klamath Lake.

Bank material is unconsolidated glaciated till, composed of 80% sands/small gravel and 20% larger material. Although large material is present in the banks, suggesting sufficient armoring, where banks are unvegetated, they are susceptible to raveling. Soil disturbances become problematic in riparian and bank areas, because it is difficult to establish vegetation in steep, raveling environments, and the stream can readily remove unsteady material.

In the lower two miles, logging and associated disturbances in riparian areas have decreased bank stability and the potential for recruitment of large woody material. Use of heavy equipment in the channel has created dry raveling along banks. Very few areas show signs of recovery. However, the resultant sediment loading is not adversely affecting aquatic habitat, as the material is quickly transported to the alluvial fan below. Riparian zone function, as a contributor of large woody material, has been adversely affected. The 1964 flood and subsequent timber harvest has left riparian zones in an early seral stage, dominated by small conifers and willows. Compaction in riparian zones and encroachment of road fill from Forest Road 3419-060 greatly increase the time required for regeneration. Conifers are returning in stands 10-20 years old, but input of large woody debris into the channel is not likely in the near future. The close proximity of the road to the stream also prevents upslope recruitment of large woody material from the north slope.

Road building and removal of the instream wood component has altered channel hydraulics. Rocks used for stabilizing fill slopes on Forest Road 3419-060 encroach on the stream channel, preventing growth of riparian vegetation and adjustment of the stream. Additionally, skid trails and temporary spur roads have detrimentally compacted areas throughout the lower reaches, especially in the vicinity of Penn Creek. Removal of large substrate for fill slopes and the woody component from the channel has decreased roughness and straightened the channel. The result is simplification of channel form and disruption of the scour-fill cycle. Lack of alluvial features indicates the dominance of the scour process. These disturbed areas, on average, contain 20% of the woody material found in undisturbed reaches. Water velocities are higher, and the retainment of fines and gravels is minimal. The number of pools has dropped proportionally to the removal of large debris. The channel is now dominated by shallow riffles in this area.

Cherry Creek

Stream densities are highest in the Cherry Creek drainage. Heads of tributaries are intermittent within the Sky Lakes Basin; surface flow is determined by lake and wetland water elevations. Leaving behind the flats of the upper plateau, water plunges toward the mainstem along the steep valley walls. Many tributaries become perennial with the break in slope, and therefore have a high potential for debris routing. These channels deliver a significant portion of Cherry Creek's sediment budget.

Cherry Creek has a moderate slope and lies in a U-shaped valley formed by glaciation. Bottom and bank sediments are developed from colluvial and fluvial processes. Direct sedimentation into high elevation tributaries from shallow, localized debris slides on precipitous slopes composed of glacial till frequently occurs (see Issue H). Depending on the gradient of a given reach, sands, gravels, or cobbles dominate the substrate. Flow energies in concert with sedimentation rates create a channel pattern of lateral/point bars, side channels, and overflow channels. Annual flood plains, as well as overbank flood plains, are well defined. The creek can be classified as a Rosgen B and C system. Generally, B reaches are in the higher gradient areas of Sections 13, 24, 21, and 22, while the lower gradient areas of Sections 19 and 20 are more typical of C channels. Additionally, B reaches are more entrenched; sinuosity and width/depth ratios are less. Floodplains in the C reaches are more developed.

Cherry Creek remains unaltered, except for the lower reach where manipulation of flow and modification of channel geometry has profoundly affected channel morphology. Seven separate water appropriations exist on lower Cherry Creek, and appropriations exceed annual low flows for most water years. Assessing diversion effects on channel morphology is difficult, due to other variables, such as channel activity and the natural division of flow in this reach (see base flow summary in Issue G).

Adjunct with the diversions, direct modification of the channel geometry has occurred. Construction of a mid-channel berm divides the flow, forcing water into the diversion canals. The berm and adjacent banks are disturbed and in an unvegetated, raveling state. The stream was also straightened and debris removed to maximize conveyance. These events reduced channel roughness and increased flow velocities. Consequently, the stream down cut and continued to degrade, until hitting a basal layer of large cobble deposited during glacial events. Tall, bare vertical banks and abandonment of the flood plain are evidence of disequilibrium. No longer able to adjust vertically, the stream is adjusting laterally. Presently, Cherry Creek is working the channel to establish sinuosity. Sinuosity will provide channel form roughness, reduce velocities, and encourage point bar formation. Point bar formation is critical for floodplain development, which is critical for stream energy dissipation.

Nannie Creek

Nannie Creek is a second-order channel with intermittent surface flow. Only one reach in Section 17 maintains surface flow year-round. Present for 1/2 mile, perennial flow goes underground with the break in slope downstream. Intermittent reaches are characterized by high gradients (>7%), large substrate, and minimal riparian zones. Below the slopes of the Cascades, Nannie Creek, like Rock and Cherry Creeks, formed an alluvial fan. Flood flows created several channels in the fan, developing new courses and filling in old ones.

According to the Rosgen classification system, Nannie Creek is predominately an A channel. The system is entrenched, with low width/depth ratio and low sinuosity. Gradients are high, with little floodplain development.

The upper two miles of Nannie Creek are in an aggraded condition. This may be a result of two different mechanisms. During infrequent runoff events, large slugs of sediment could be introduced into the creek. For example, the 1964 flood was more than capable of delivering large amounts of glacial till to the stream channel. Due to the intermittent flow regime, the time needed for re-establishment of a single channel after such an event would be considerable.

The second mechanism is a result of past activities in the drainage. Road construction and logging activities near the stream channel have altered channel morphology. Logging and associated activities in riparian zones have not only removed filtering vegetation and large woody debris recruitment, but also greatly increased sediment production. Road systems, due to improper drainage and too few culverts, channelize water and sediments directly into the stream. Historically, during most years, the rate of sedimentation into the system was probably low due to the intermittent nature of the watershed. The transport capacity of the channel was also low, maintaining a balance of input and transport. With the increased sedimentation rate caused by management activities, this equilibrium is no longer present.

Direct modification of the channel has also altered the dynamics of Nannie Creek in the lower reach. It is now channelized and connected to the Cherry Creek canal, which empties into the Fourmile Canal. The lower reach of Nannie Creek is no longer able to adjust and spread out over the alluvial fan.

There is little doubt that management activities have influenced channel morphology in Nannie Creek. The crux of the debate is, "what is the relative contribution of natural and unnatural sediment delivery to the aggraded system?" This identifies a need for monitoring.

In the future, roads will continue to route water and sediments during most rain and snow melt events unless drainage improvements are initiated. Further speculation on trends and future conditions will depend on monitoring results.

DESIRED FUTURE CONDITION

In all three drainages, the distribution of mature conifers along the stream channel is returning to pre-harvest levels. Riparian zones are contributing large woody debris to the system. Riparian zones are functioning as energy dissipators to maintain form and shape of the channel during large, infrequent runoff events. Channel roughness and development of floodplains have returned, re-establishing an equilibrium of scour and fill. Water and sediment routing from roads are minimized by proper culvert placement and road surface drainage.

G. ISSUE: The hydrograph has been altered, in terms of base flow, peak flow, and timing of peak flow.

KEY QUESTIONS: Has the natural drainage process in the watershed been altered by timber harvest, road building, and diversion activities?

ANALYSIS PROCEDURE

The watershed area was divided into the Rock, Cherry, and Nannie sub-basins. The first step was the quantification of the present flow regime. Comparing current flows to historical flows was not feasible due to data limitations, but, based on the distribution and intensity of management activities (cumulative effects) in the watershed, the probabilities of change were estimated.

Base flow analysis procedure

Base flows were ascertained from sketching hydrographs from the 1992 and 1993 water years. The hydrographs consist of several miscellaneous measured flows. Flow information is not available for Nannie Creek. Inflection points in the Rock and Cherry hydrographs were identified and used to determine annual low flow. For Nannie Creek, the limits of ephemerality (extent of perennial flow) were used. It is important to note that 1992 was a drought year, while 1993 had above average precipitation. Although total water yield differed significantly in 1992 and 1993, base flows did not.

Peak flow analysis procedure

Peak flows at a 2-year return interval were used for this analysis. The 2-year return interval was chosen because of the inherent channel-forming properties associated with this stage. Because the product of the frequency and magnitude of the forces of discharge determines the effectiveness of sediment transport and the resultant channel characteristics, it can be inferred that the active channel is formed by frequently occurring medium-sized events (Wolman and Miller, 1960). While larger events modify floodplains and valley floors, they are too infrequent to maintain the active channel.

Peak discharge was quantified using United States Geological Survey (USGS) gauging statistics and miscellaneous flow measurements. Gauging station data indicate that in the Klamath Basin, there was, on average, a 3-4 year event during the wet year of 1993. Although there are differences in runoff patterns between the rivers with gauging stations and streams on the east slope of the Cascades, it is fairly certain that creeks in the watershed area experienced similar peak flows. During the peak runoff, discharge measurements were taken in Rock and Cherry Creeks. A number of discharge measurements were made during the "over-the-bank stage" (while the floodplain was inundated). While an exact number for the two-year return interval peak flow cannot be made, a range of flows around this interval was quantified; peak flow is expected to fall within this range.

Cumulative effects analysis procedure

In developing a conceptual model and forming assumptions for factors leading to changes in flow regime, findings from the Pacific Northwest and Intermountain Forest and Range Experimental Stations (e.g. Bethlahmy and Nedavia, 1972; Cline et al., 1977; and Harr et al., 1979) were used, as well as Dennis Harr's summaries at Oregon State University (Harr, 1975; Harr et. al, 1975) and several papers included in the International Symposium on Forest Hydrology (Dortignac, 1965; Pereira, 1965).

Modification of vegetation distribution was assumed to be the dominant factor influencing changes in base flow. Changes in vegetation structure and resulting changes in transpiration rates are directly proportional to changes in soil moisture content, which are directly related to base flow conditions.

The net effect of loss of interception, difference in winter melt, and design of the road system was assumed to be most influential in altering quick flow and peak discharge. The fundamental concepts underlying these assumptions follow: loss of interception will increase snow accumulation; changes in canopy closure will change solar radiation input; and the presence of roads add to the drainage network. "Net effect" was chosen because all three factors are simultaneously involved. Consequently, determining the relative contribution of any one variable is not significant.

These assumptions focused the cumulative effects analysis on recovery rates of harvested units and road densities. Recovery rates were determined for units harvested during the past 25 years. In the absence of a model designed for this area, recovery rates for each harvested unit were assigned through discussions among team members and the District silviculturist. (A model is currently being developed on the District). Aerial photo interpretation and field verification were used. Factors considered included the harvest prescription, year cut, and reforestation effort. To standardize the data and facilitate comparisons among watersheds, all harvesting was expressed in terms of equivalent clearcut acres (ECA). Temporally, literature indicates the maximum difference in streamflow response generally occurs the first five years proceeding harvest and decreases logrithmically with time. "Recovered" in this analysis is considered to be "hydrologically recovered". Units are hydrologically recovered when re-establishment of root systems is sufficient to return soil moisture content to pre-harvest levels and canopy closure is sufficient to prevent excessive snow accumulation. Roads and areas of compaction are not incorporated in the recovery model as these conditions persist for long periods of time.

Changes in vegetation resulting from alteration of the fire regime (see Issue A) were considered, but not quantified during the analysis. In the lower elevation white fir mixed conifer stands, succession in the absence of fire has caused a shift from ponderosa pine-dominated stands to white fir-dominated stands. This has resulted in higher stocking levels and increased canopy closure in some stands. The change has likely increased transpiration rates. Reduction of snow accumulation has probably been minimal, since typical ponderosa pine stands originally had 40-70% canopy closure. Therefore, the largest effect may be on the availability of water during late summer. This process may influence base flows if stocking levels increase on a significant portion of the watershed area.

DISCUSSION

Rock Creek

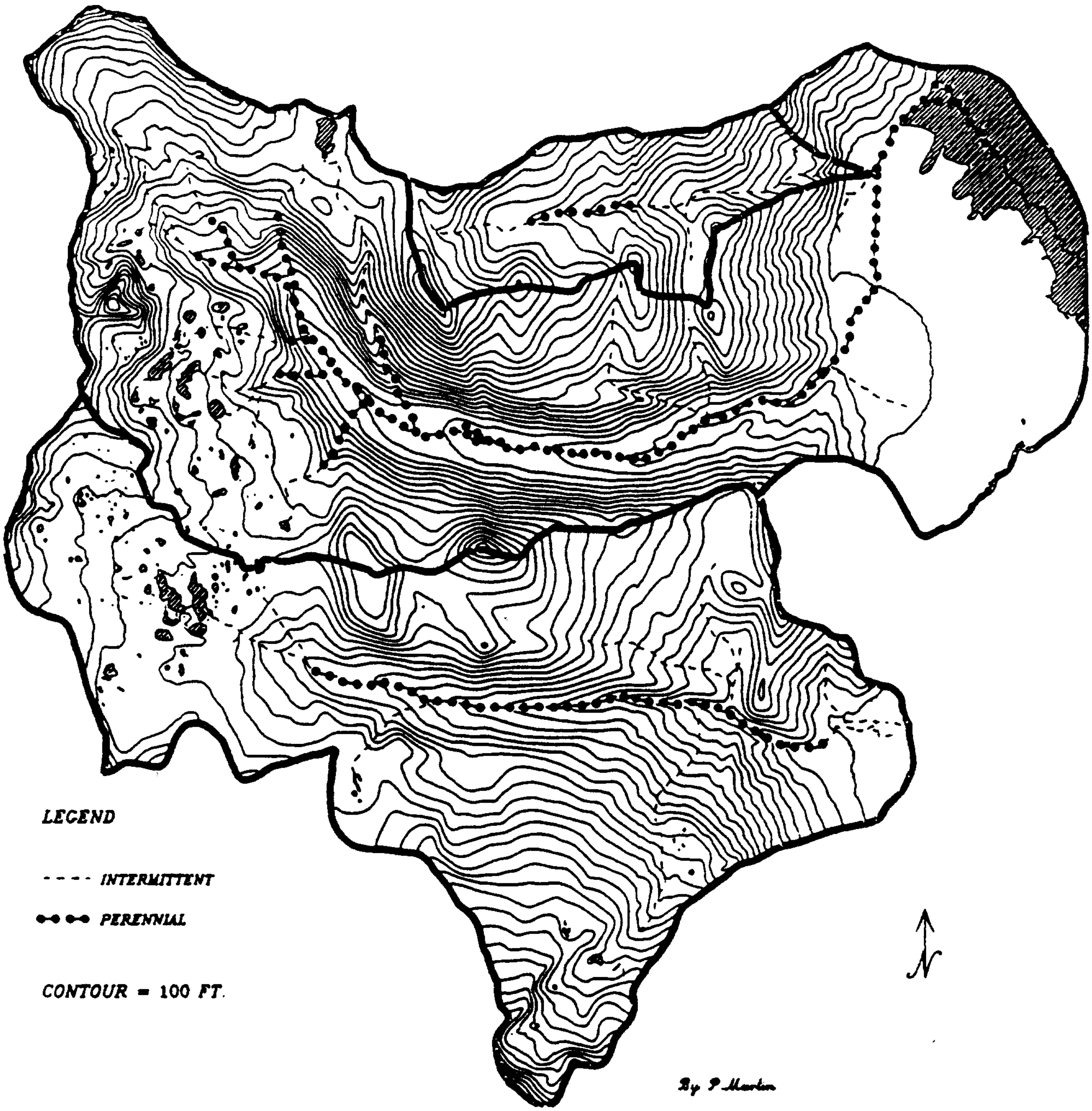
The mainstem is a third order channel and the only perennial reach in the drainage (Map 9). Tributaries have a dendritic pattern, and are very coarse. Stream density at the headwaters is .35 stream miles per square mile of watershed area. First and second order channels are restricted to the glacial cirque, which comprises less than 1/3 of the wilderness area in the drainage. Rock Creek is a tributary of Upper Klamath Lake; connectivity to the lake is intermittent. Rock Creek reaches Upper Klamath Lake via Recreation Creek during spring runoffs. At other times of the year, flows subside into the alluvial fan before reaching Recreation Creek. Table 1 lists basin parameters for all three creeks.

Currently, the base flow of Rock Creek is .1 cfs (cubic feet per second) which "subs out" (goes underground) approximately 100' above the bridge on Forest Road 3419, depending on the water year (Figure 3). Springs in Section 35 provide the major source of water for Rock Creek during low flow periods. Comparing Rock Creek's base flow with other streams in the area, it appears to be aberrant. Specifically, analysis on basin parameters indicates that a substantially lower flow exists in Rock Creek than in the other streams. This anomaly is best explained by the geology of the Rock Creek watershed, rather than differences in management activities. Tectonic forces have created many fractures with steep hydraulic gradients. With many springs at the contact zone between the steep slopes of the Cascades and flat lands of the Klamath Lake Basin, it is speculated that much of the upper watershed is a recharge area for an aquifer which discharges at this contact zone. Additionally, many hydrologically closed lakes exist in the upland plateau, created by glacial forces and sealed by Mt. Mazama ash, forming an effective aquatard. The result is a large storage capacity and retention within the watershed.

	ROCK CREEK	CHERRY CREEK	NANNIE CREEK
Watershed Area (mi^2)	16.8	16.8	3.5
Stream Length (mi)*	7.6	9.0	2.4
T. Stream Length (mi)**	14.1	21.3	3.8
MN Basin Elev. (ft)	5742	5729	5634
MN Basin Precip. (in)	47	47	46

* Stream Length calculated from monitoring site to summit.
** T. Stream Length includes above plus tributary miles.

Table 1. Basin parameters for Rock, Cherry, and Nannie Creeks.



MAP 9. ROCK, CHERRY, AND NANNIE CHANNEL NETWORK

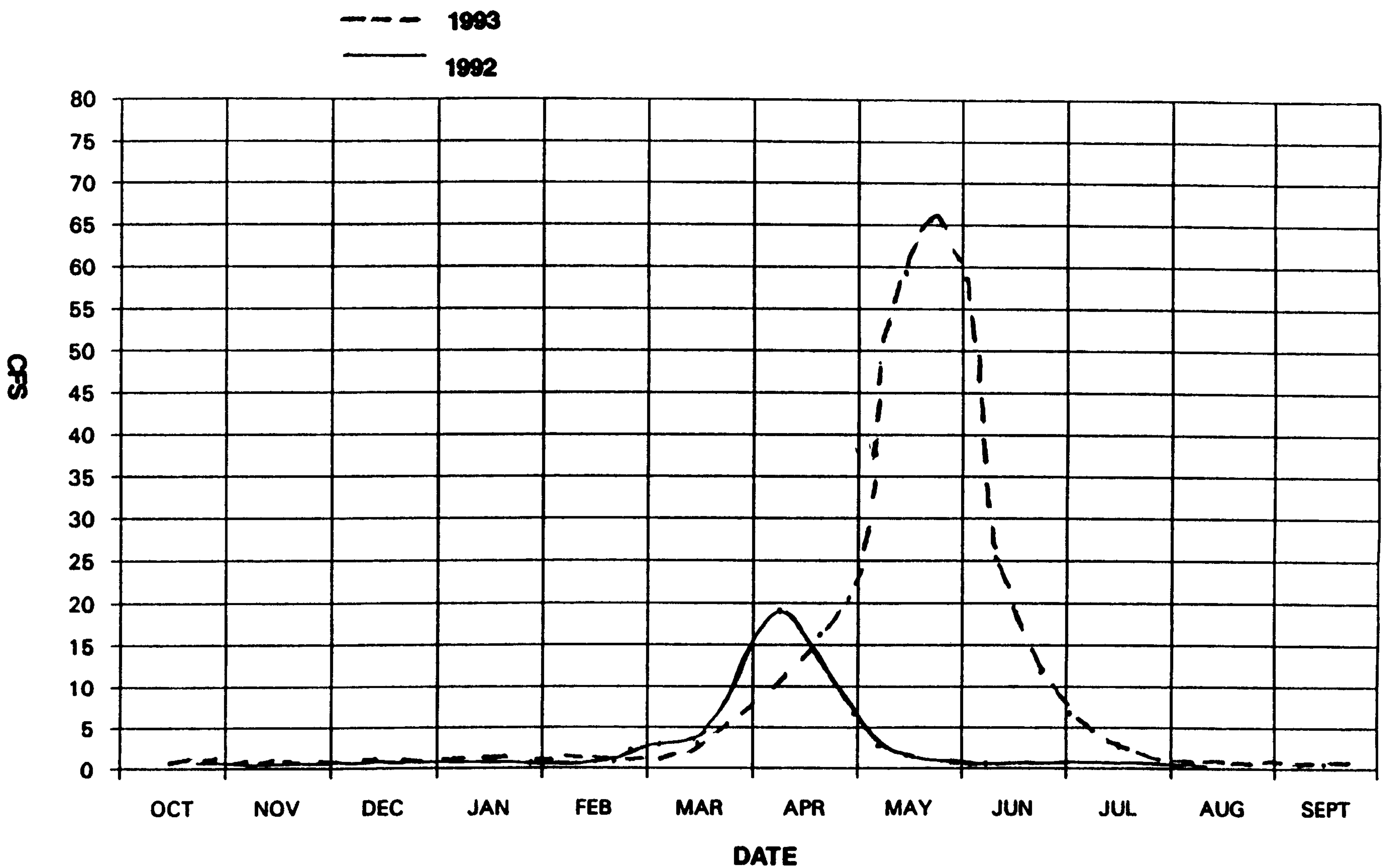


FIGURE 3. ROCK CREEK HYDROGRAPH

Peak flow for Rock Creek is 50-65 cfs. As with base flow, peak flow is low when compared with other streams in the vicinity. The explanation above provides insight as to the reasons for this.

Harvest activity in the Rock drainage during the last 25 years consisted of overstory removals, thinnings, and shelterwood cuts, which removed 10-80% of the basal area present in the units; and clearcuts. Clearcut units were typically less than 40 acres in size. Only two units were larger, both being 50 acres. Although prescribed as clearcuts, many 4 to 9-inch diameter trees remained in the units. Regeneration units were reforested with an average of 400 trees per acre; many units were planted more than once. The process described under the cumulative effects analysis procedure was used to estimate that currently, the Rock drainage has 419 acres of equivalent clearcut acres. This represents 3.6% of the total area.

There are 171 acres of road surface and an additional 2,076 acres of compacted surface from timber harvest activity in the Rock drainage. Field reconnaissance indicates that there is little overland flow or surface erosion occurring in the compacted areas, except on non-native road surfaces. This is due to the build up of a duff layer and the high percent of course material in the soils, allowing for rapid infiltration. While roaded acreage is less than 2% of the Rock drainage, the density of roads within .25 miles of Rock Creek and its tributaries raises concern about effects on peak flow timing. However, in comparing the peak flow timing of Rock Creek with Cherry Creek, which has low road densities adjacent to its tributaries and main channel, there appears to be no appreciable difference.

Fire suppression has little affected the hydrologic budget of Rock Creek. Many low elevation stands in the drainage were originally dominated by white fir and had 70-100% canopy closure (based on 1940's and 1950's aerial photos). Since 1940, the amount of area in the drainage with >70% canopy closure has declined from 31% to 23%, primarily a result of the effect of timber harvest in the white fir mixed conifer and Shasta red fir zones.

In summary, 3.6% of the Rock Creek watershed consists of equivalent clearcut acres. There has not been enough reduction in vegetation from logging to significantly decrease transpiration and alter base flow. Similarly, openings created by harvesting are small and isolated. The effects on peak flow from increased snow accumulation and solar radiation input in these openings is minimal. Succession resulting from fire suppression has had little effect on transpiration. Roads do not appear to be affecting peak flow timing. Overall, the natural drainage process in the Rock Creek watershed has been modified in localized areas, but concern about changes in the flow regime is low.

In the future, timing and quantity of water flows will remain in a relatively unmodified condition, as long as future management direction includes provisions for late seral and riparian reserves. Roads will continue to route water to the stream. However, at present road densities, this influence on quick flow processes is not detectable.

Cherry Creek

The mainstem of Cherry Creek is a third order channel and is entirely perennial. Many first and second order channels are perennial as well, fed by lakes or springs. In the wilderness, comprising 1/2 of the basin area, the stream pattern is dendritic and medium coarse, with a stream density of 1.35 stream miles per square mile of the drainage area. Cherry Creek is a tributary of Upper Klamath Lake, historically connecting via Fourmile Creek.

The base flow of Cherry Creek is 9 cfs above the irrigation diversion in Section 22 (Figure 4). Baseflows are largely maintained by springs, predominately located in the upper watershed in Sections 19, 24, 13, and 14. Below the diversion, base flow was 5 cfs during the 1993 water year, and dry in 1992 and 1994 water years (Figure 5). Although this appears to be the result of water withdrawals, aerial photos indicate Cherry Creek historically split into three channels. Division of flow among channels would have greatly reduced the flow in any one channel, as currently occurs with the diversion. However, it is likely that prior to flow regulation devices, discharge varied over time among channels and over space on the alluvial fan.

Many lakes exist on the wilderness plateau in the Cherry Creek drainage, creating hydrologic storage areas. Unlike the Rock Creek drainage, many of these lakes are not closed, but are linked together via a stream network and eventually flow into Cherry Creek, contributing to a higher base flow.

Peak flow for Cherry Creek is 100-130 cfs above the diversion and approximately half that amount below the diversion. As mentioned above, below the diversion, Cherry Creek originally split into three main channels, which either flowed into Fourmile Creek or directly into the marsh. These unconfined channels moved across the alluvial fan, changing direction with large, infrequent floods. This process has been considerably altered due to water withdrawals and channelization. Existing channels have been transformed into diversion canals. Water in excess of irrigation needs is channelized into Fourmile Spring which flows into Fourmile Canal. Water in Fourmile Canal is directed through a series of dikes before entering either Sevenmile Creek or Upper Klamath Lake.

Cumulative Effects

More than half of the Cherry Creek drainage area lies in the Sky Lakes Wilderness and has been relatively unaltered by human activities. This high elevation area also comprises the majority of the water yield recruitment area. Harvest activity has been minimal during the last 25 years. Acres of equivalent clearcuts comprise less than 1% of the drainage area. Roads total 158 acres, representing 1% of the area.

Fire suppression has led to replacement of ponderosa pine with white fir in some stands, increasing canopy closure by as much as 30%. The extent is limited to lower elevations and southern aspects, which comprise about 10% of the drainage. In these areas, evapotranspiration rates have likely been altered. Because the relative difference in transpiration rates between ponderosa pine and white fir stands is not fully understood, it is unknown at what point increasing the canopy closure will begin to influence base flows. It is unlikely that the current spatial extent of stands with increased canopy closure is large enough to affect the flow regime.

In summary, only 1% of the watershed consists of equivalent clearcuts. There has not been enough reduction in vegetation from logging to significantly decrease transpiration and alter base flow. Similarly, openings created by harvesting are small and isolated. The effects on peak flow from increased snow accumulation and solar radiation input in these openings are minimal. Roads cover only a small portion of the drainage area. The effects of succession resulting from fire suppression are unknown. However, overall, it is unlikely that flows have been significantly altered above the diversion. In the reach below the diversion, flow is continually manipulated and, hence, the hydrograph varies from year to year.

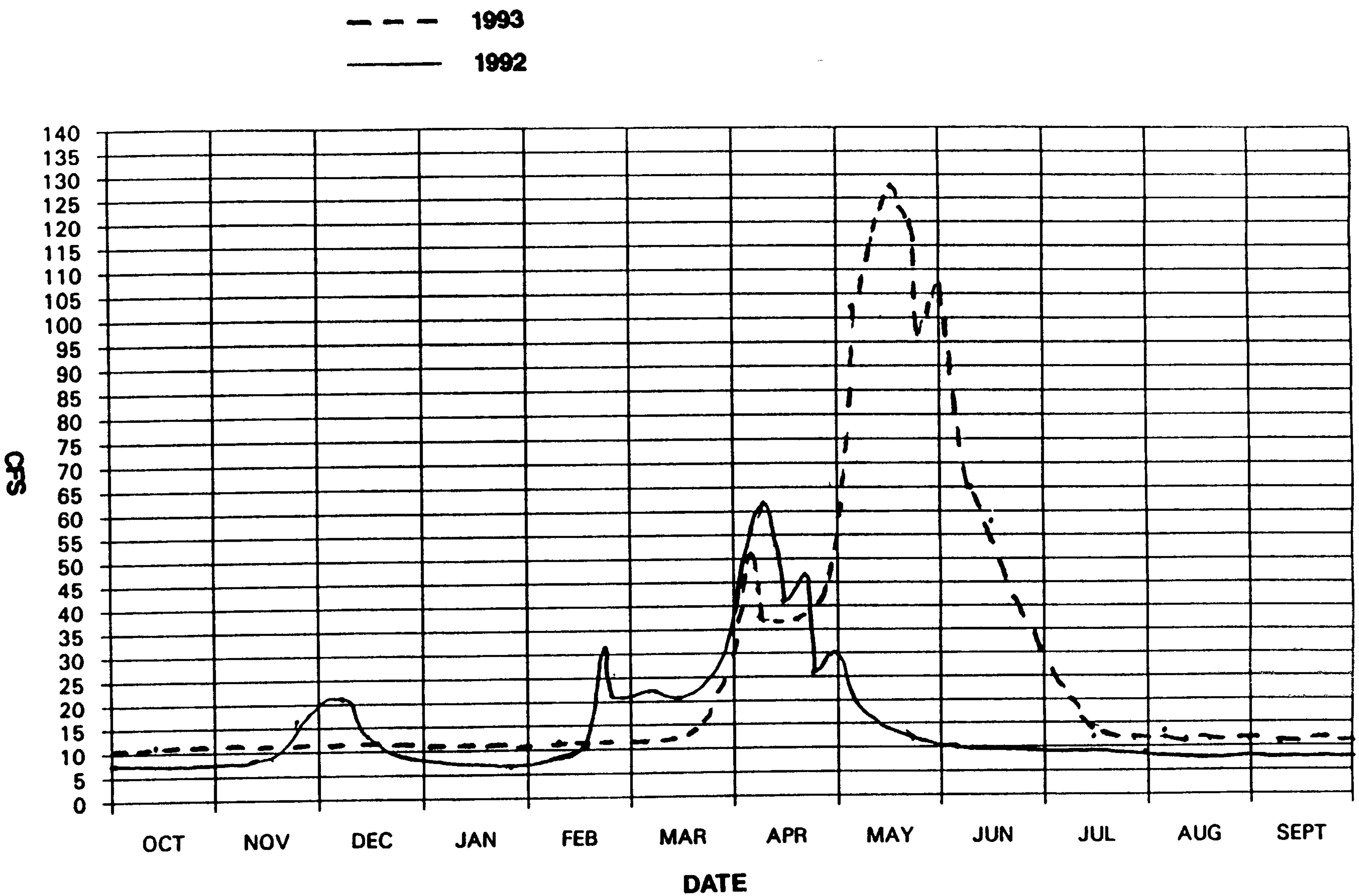


FIGURE 4. CHERRY CREEK HYDROGRAPH ABOVE THE DIVERSION

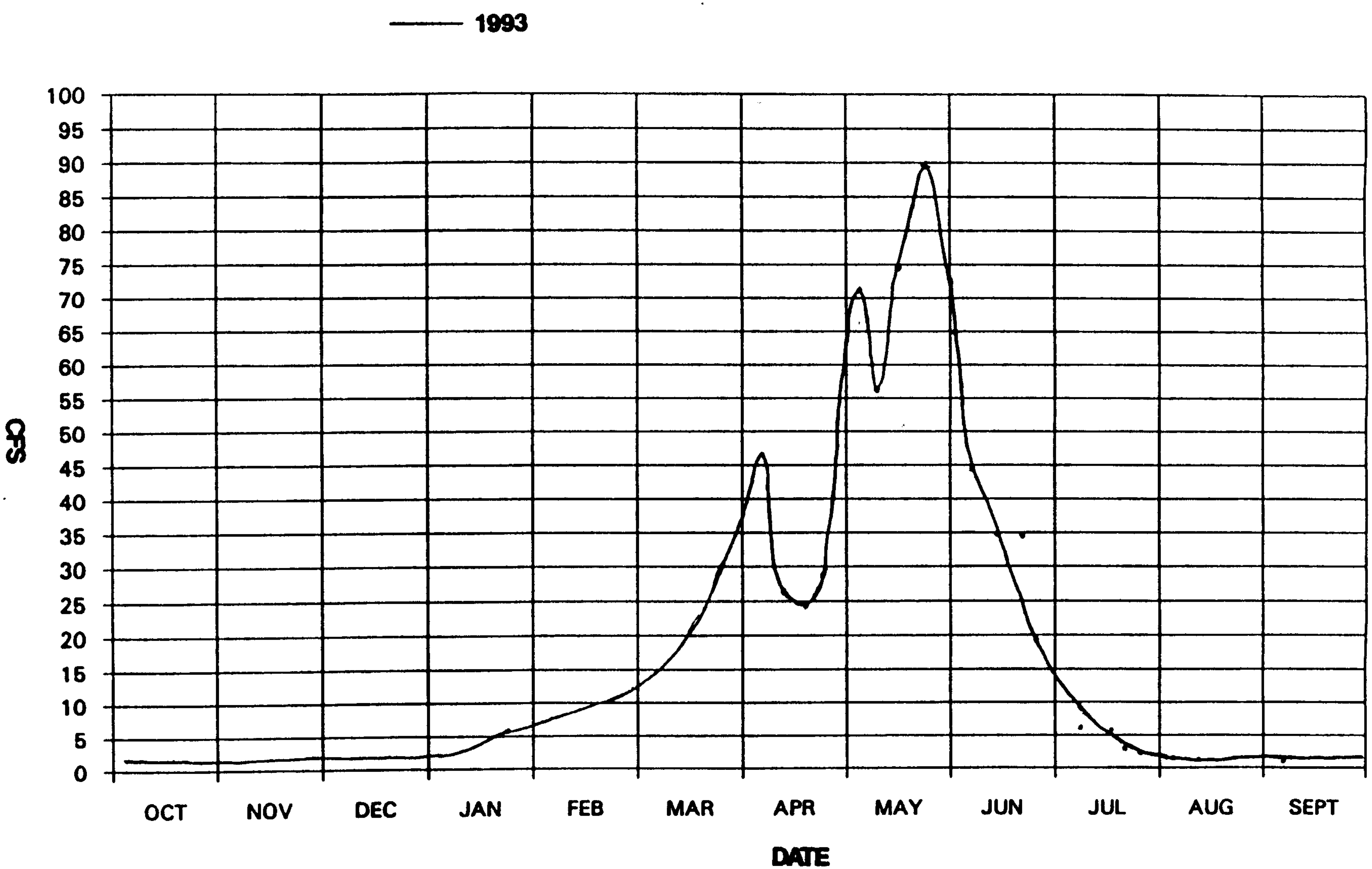


FIGURE 5. CHERRY CREEK HYDROGRAPH BELOW THE DIVERSION

Above the diversion, the timing and quantity of water flows will remain in a natural condition, as long as management direction includes provisions for late seral and riparian reserves. In the reach below the diversion, management of flow regulations will dictate the future condition of the hydrograph.

Nannie Creek

Analysis of base flow for Nannie Creek consists of observation only. Nannie Creek is a second order stream with a drainage area half the size of Rock or Cherry Creek. Surface water is maintained within Section 17 for approximately 1/2 mile through a lodgepole/meadow environment. Flows subside with the increase in gradient downstream.

The peak flow of Nannie Creek was estimated due to a lack of data. An estimate of 18 cfs was made by using a flow:basin area ratio developed with data from Threemile Creek to the north, and Cherry Creek to the south.

Modification of the lower reach has significantly altered the routing of water. Nannie Creek is an intermittent tributary of Klamath Lake. During spring runoff, water historically reached either Fourmile Creek or the north fork of Cherry Creek. Since both the north fork of Cherry Creek and Nannie Creek were subject to rapid adjustment during flood events, the past location and interaction of channels at any given time is difficult to assess. Currently, adjustment is not possible as the lower reach is now channelized to Fourmile Spring, which flows into Fourmile Canal.

Cumulative Effects

Harvesting during the past 25 years consisted of overstory removals, thinnings, shelterwood cuts, and clearcuts. Regeneration cuts ranged in size from less than 10 acres to 143 acres. Most regeneration units were reforested with an average of 200 trees per acre. The Nannie Creek drainage is estimated to currently have 193 acres in equivalent clearcuts. This represents 9% of the drainage area.

There are 42 acres of road surface in the Nannie Creek drainage, totaling 1.9% of the area. There are an additional 504 acres of compacted surfaces, resulting from timber harvest activities, which total 25% of the drainage area. Within harvest units, very little evidence of puddling or overland flow exists; build-up of a duff layer and a high percent of course fragments in the soils accounts for this. The real concern regarding compaction in the Nannie Creek drainage is not the amount, but the location. Roads run along nearly the entire length of the channel and cross the mainstem in five locations.

Proportionally, the Nannie Creek drainage has been most affected by alteration of the fire regime. The amount of area with 70-100% canopy closure has increased from 2 to 27% since 1940. Two factors have contributed to this figure, natural reforestation of past burn areas in the upper elevations and replacement of ponderosa pine with white fir on south-facing slopes and at lower elevations. It is assumed that these changes have influenced base flow by decreasing soil moisture content. The overall effects on base flow resulting from the opposing effects of succession, which may increase transpiration, and timber harvest, which may decrease transpiration, are too complex to predict with current information. Because this question concerning the effects of succession on hydrology is likely to be raised in many watersheds on the District, personnel will conduct further investigation in 1995. In the Rock, Cherry, and Nannie watershed area, the effects of succession on forest health and wildlife habitat currently appear to be larger issues and will drive management recommendations.

The intensity and spatial extent of logging, together with road location and density, have probably been sufficient to modify quick flow processes. Canopy openings have created opportunities for snow loading and increased solar energy input. Road systems with improper drainage in and near Nannie Creek provide efficient routing for the increased snow melt. The probability that management activities have increased storm runoff timing is low to moderate.

In the future, stream flow in Nannie Creek will remain intermittent. Roads will continue to accelerate runoff during snow melt and rainstorm events. Harvest units will recover in approximately 20 years. Management plans which include late seral and riparian reserves will greatly reduce the potential for future changes in the hydrograph.

DESIRED FUTURE CONDITION

For all three creeks, the desired future condition is maintenance of the current quality and quantity of water delivered by the watersheds.

H. ISSUE: Increased sediment loading is occurring in the creeks.

KEY QUESTIONS: Do landslides and debris flows occur in the watershed area, are they contributing to sediment loading, and have management activities increased their occurrence?

Have past management activities influenced the rate of upland erosion and does sediment from upland erosion enter the streams?

DISCUSSION

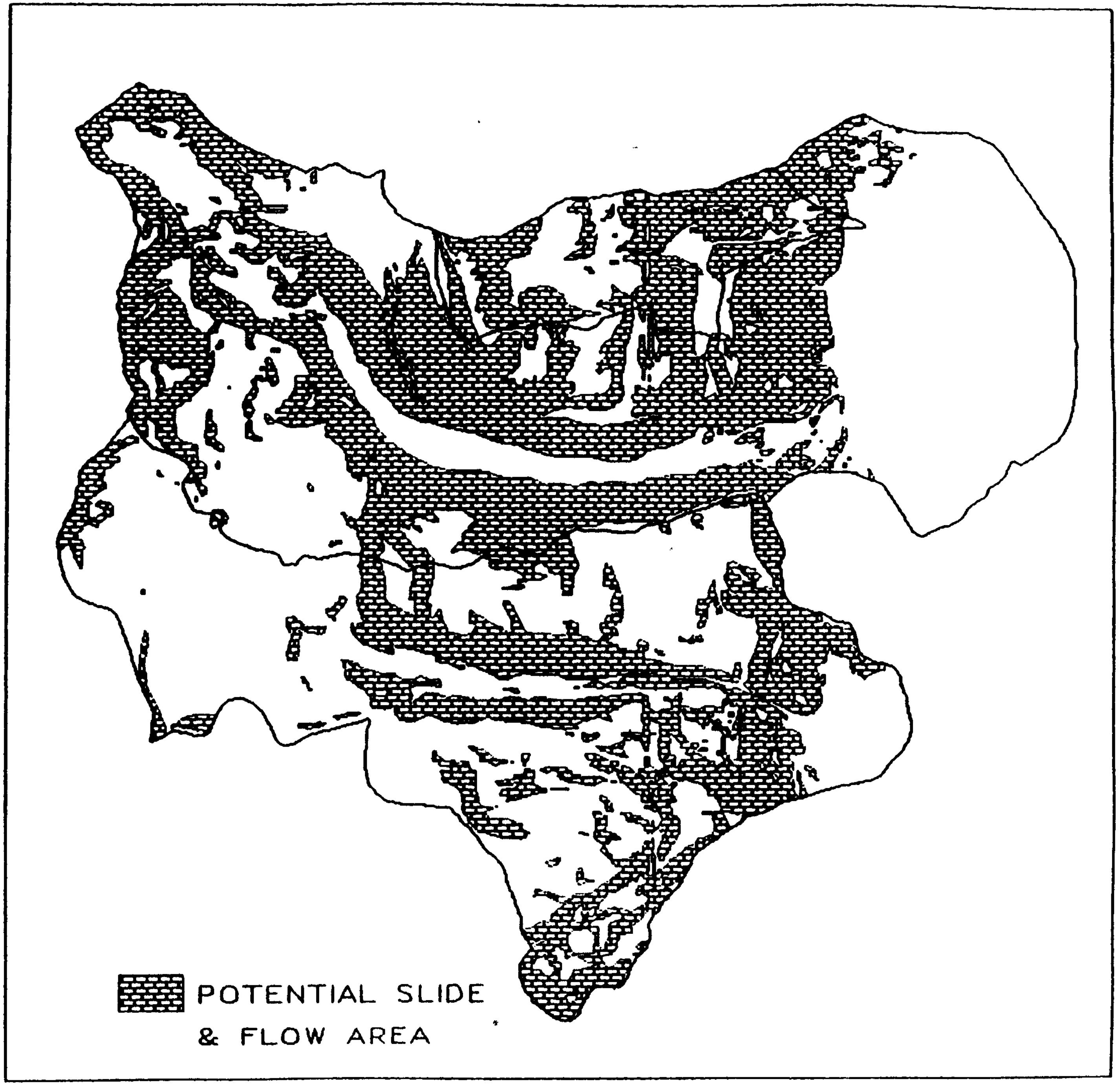
LANDSLIDE/DEBRIS FLOW ASSESSMENT

Two types of landslides were analyzed in the Rock, Cherry, and Nannie watershed area: debris slides and debris flows.

Debris slides are characterized by rapid downward movement of predominantly unconsolidated and incoherent soil and debris in which the mass does not show backward rotation, but slides or rolls forward, forming an irregular, hummocky deposit. Movements are relatively dry. Debris slides occur most frequently on steep talus or other detrital slopes with a lack of vegetative ground cover, where the disturbance of a single boulder may be propagated downhill, producing a slide. Debris slides are usually rather small and are such common phenomena that they are seldom recorded in detail.

Debris flows are characterized by shallow soil or unconsolidated soil material, steep slopes, long slope gradients, and a reduction of vegetation. Unlike debris slides, debris flows occur when soils become saturated with water. Soil saturation increases the shear force over the shear resistance, reducing the internal friction and acting as lubrication in initiating debris flows. Rainfall is generally accepted as one of the chief factors controlling the frequency of debris flows. Other factors include slope steepness and length and climatic fluctuations. Drought conditions can play a key role in reducing the cohesion of soils. As soils dry out, they shrink, creating faults or cracks. This makes it easier for water to infiltrate, and soils reach saturation sooner.

Debris slides and debris flows are visible on aerial photos of the watershed area, dating from 1940 to the present. They occurred primarily in areas with slopes greater than 70%, shallow soils with less than 30 inches to bedrock, unconsolidated till, and unconsolidated basalt flows. Most slides were located in the high elevation areas of the Sky Lakes Wilderness in both the Rock and Cherry drainages. These upper elevation areas are characterized by unconsolidated till, a naturally sparse vegetative cover, and slopes 70% or greater. Map 10 shows areas with slopes greater than 70%, which have potential for slide and flow occurrence. Occurrence of slides in the high elevation areas was widespread and variable. Slides ranged from a hundred feet to half a mile long. Due to the instability of the parent material, slides may remain active for many years, as observed on sequentially-dated aerial photos.



MAP 10. AREAS WITH POTENTIAL FOR OCCURRENCE OF DEBRIS SLIDES AND FLOWS

Debris flows occurred primarily on the south-facing slopes of the upper Rock drainage and mid-to-upper Cherry drainage. Few debris flows were located in the mid-to-lower Rock and entire Nannie Creek drainage. These areas have shorter slope lengths and varied slope gradients, which result in less chance for critical soil saturation. Occurrence of debris flows was infrequent. In all years, visible flows totaled much less than 1% of the watershed area. The largest number can be seen on 1965 photos. These occurred subsequent to a 100-year rain-on-snow flood event (Christmas Flood) in 1964. Debris flows on 1965 photos were concentrated on the south-facing slope of the Cherry drainage, but also occurred throughout the watershed area.

Debris slides and flows have contributed to the natural sediment loading in all three streams. Historically, debris flows mainly occurred during high precipitation years and debris slides occurred with greater frequency. It is therefore likely that debris slides contribute more to the natural sediment loading of the streams. Except in Nannie Creek, most of the sedimentation occurs in tributaries, rather than direct loading into the mainstems. The majority of the tributaries are in the Sky Lakes Wilderness, where slopes are steep and soils are shallow. Shallow, unconsolidated till materials occur from the ridge lines down to the edge of many of these tributaries. Sediment collects in the tributaries and is carried to the main channels when tributaries flow water. There is no aggradation evident in the stream channels in the wilderness, indicating that under natural conditions, the amount of sediment entering the streams does not exceed the transport capacity.

In the 1970's, debris slides and flows were promoted by logging on steep slopes. The reduction of vegetative ground cover increased the potential for soil saturation, leading to more slides and flows. This is evident on 1975 and 1979 aerial photos, where slides increased from an average of 0-5 per year to 3-8 per year on harvested slopes. It is likely that sedimentation increased as a result. To a lesser extent, slides and flows associated with logging can been seen in other years, as well. Because the Rock and Nannie drainages have a higher percent of their area in timber management than the Cherry drainage, they have been more susceptible to debris slides and flows associated with harvesting.

Since the late 1980's, debris slides and flows have returned to more natural levels of occurrence. This follows a reduction in timber harvest and re-establishment of vegetative ground cover. Currently, there is no evidence of sediment accumulation in Rock and Cherry Creeks outside the wilderness. This suggests that the equilibrium of these systems has not been significantly altered by past management activities, or has returned to natural conditions, following the reduction of timber harvest. In the Nannie Creek drainage, due to the lower frequency of debris slides and flows, sediment inputs from these sources are minor.

SUMMARY

Debris slides and flows naturally occur in all three drainages. Debris slides occur more frequently than flows, which are primarily associated with high precipitation years. The Cherry Creek and Rock Creek drainages have the highest incidence of debris slides. Past logging on steep slopes has increased the occurrence of debris slides and debris flows by reducing the amount of vegetative ground cover. Debris slides input sediment primarily into the tributaries of Cherry and Rock Creeks and directly into the mainstem of Nannie Creek. Presently, Rock and Cherry Creeks have adequate flows to transport the sediment downstream. Inputs of sediment from debris slides and flows into Nannie Creek are minor. In the future, debris slides and flows will likely occur at historical frequencies in the wilderness and be caused primarily by natural processes. Outside the wilderness, implementation of the standards and guidelines in the President's Forest Plan are expected to limit slides and flows associated with logging.

DESIRED FUTURE CONDITION

Debris slides and flows continue to occur at low levels as a result of natural processes. Management plans evaluate and take into consideration debris slide and flow potentials. Management activities are planned to protect areas where a high potential for occurrence of slides or flows exists.

UPLAND EROSION ANALYSIS

Upland erosion includes sheet and rill erosion and gullying processes. It occurs when small aggregates or individual soil particles from the surface horizon are mobilized. Erosion of soil sediments results from two physical processes: detachment and transportation. Detaching forces include glacial ice; excessive tillage; wind; flowing water; and crushing by vehicles, heavy machinery, animal hooves, and people's feet. Transporting forces include glacial ice; gravity; strong wind; and the current primary force in the watershed area, flowing surface water.

The amount of force needed for the erosional processes of detachment and transportation to begin are dependent on slope, soil texture, infiltration rates, compaction, and vegetative ground cover. Slope influences the occurrence, rate, and intensity of erosional processes. For example, the carrying capacity of water increases very rapidly with an increase in velocity, and the velocity of flowing surface water is dependent on slope. Therefore, the greater the slope, the higher the probability for erosion to occur, and the larger the magnitude of the event.

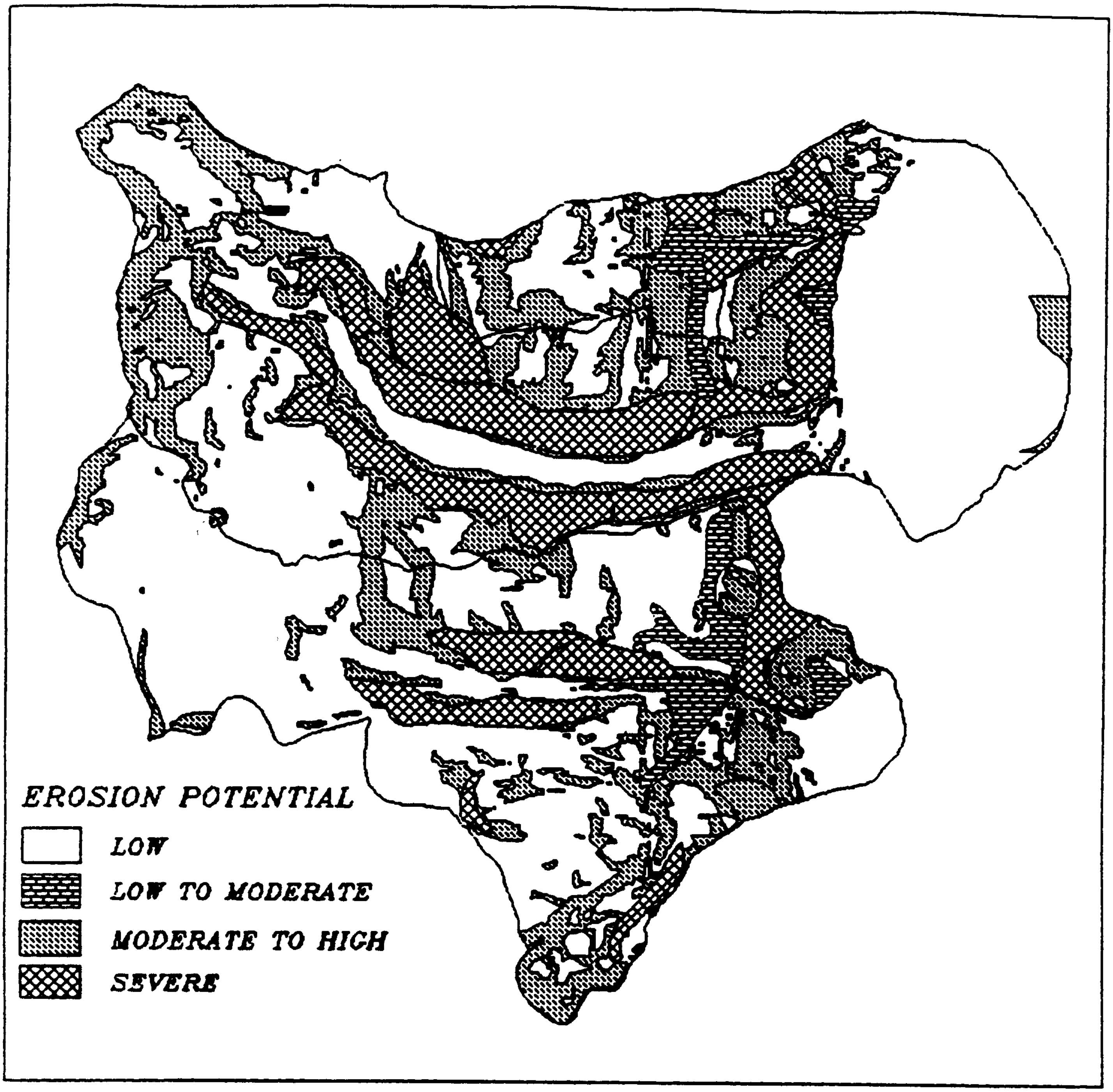
Soil texture also plays a key role in determining the magnitude of an erosional event. Soils which contain higher percentages of fines, silts, and clays will be more susceptible to detachment and transportation. Infiltration rates are determined by the time it takes for water to percolate down through the soil layers. Compaction slows infiltration. Slower infiltration rates promote surface water flow, which in turn promotes initiation of erosional processes. Unvegetated areas provide a highway for the transportation of detached soil particles. In areas devoid of vegetative ground cover, water erosion of soil starts when raindrops strike bare soil peds and clods, causing finer particles to move with the flowing water as suspended sediments. Little force is needed in such areas to initiate detachment and transportation. Combinations of the above factors increase erosion further. Areas with compacted surfaces, steep slopes, and lack of vegetation have higher runoff velocities, thus producing higher erosion rates.

Map 11 shows areas with potential for upland erosion. Erosion potential is rated as low, low to moderate, moderate to high, or severe, based on soil type and slope. Map 11 does not take into account past management activities, which may locally increase the potential for erosional processes to occur. Approximately 90% of the watershed area has slopes which could be susceptible to erosional processes. Upland erosion can occur when slopes are greater than 5%, but generally does not become a problem until slopes are 25% or greater. The potential increases in magnitude and frequency with steeper slopes. Soils within the analysis area vary from 20-70% fines. The higher percentages are found in flatter areas, while steeper slopes have a higher rock content. Infiltration rates are described as moderate to moderately high in the watershed area (Carlson, 1979).

Historically, upland erosion occurred primarily after wildfires removed overstory and ground vegetation. Stand-replacing events allowed for precipitation to directly impact the soil. In more recent times, logging and road building activities have been more important in removing vegetation than fires. These activities have resulted in the exposure of bare ground, leaving it susceptible to erosional processes.

Activities associated with logging, such as skid trail and landing construction and use, cause soil exposure, disturbance, and compaction. However, currently, skid trails and landings do not appear to promote significant erosion. This is due to their disjunct pattern. Soil infiltration rates in adjacent areas are moderate to moderately high. When overland flow occurs on skid trails and landings, it runs off onto less compacted and disturbed soils, where water can infiltrate, thus ending the overland flow and erosional process. Past clearcutting probably resulted in a similar effect, with the exception being that soil movement was probably much higher and decreased rapidly with revegetation. Units in close proximity to streams likely caused the greatest increase in sediment input to the creeks. Prior to signing of the Winema Forest Plan and implementation of stream buffers, logging next to stream channels occurred. It can be assumed that with the decrease in harvesting beginning in the late 1980's, revegetation of existing harvest units, and use of stream buffers, this effect has lessened in recent years. Although harvest units, skid trails, and landings do not currently appear to be causing sedimentation in the creeks, the overall magnitude of soil compaction and disturbance from these activities in the watershed area still presents a concern. Further investigation of the effects of soil compaction should be conducted.

Roads were determined to have the greatest effect on increased sediment input to the creeks. Roads comprise 1.25% of the entire watershed area. There are 32.56 miles or 158 acres of roads in the Cherry Creek drainage, 35.23 miles or 171 acres in the Rock Creek drainage, and 8.68 miles or 42 acres in the Nannie Creek drainage. The Nannie Creek drainage has the highest concentration of roads outside the wilderness, covering 2.5% of the area. Roads are a problem where they have close proximity to the creeks and/or are connected to the creeks. Eleven percent of the roads in the watershed area lie within 200 feet of one of the creeks. Due to their extremely compacted, non-vegetated surfaces, some roads have become an extension of the stream network, funneling precipitation and sediments into stream channels and tributaries. Tributaries have also been dissected with roads in many cases. Specific areas of concern include: all road crossings; Forest Road 3484, which parallels Nannie Creek; the high density of roads in T34 R6S Sections 33 and 34 of the Rock Creek drainage; and Forest Road 3419-060, paralleling Rock Creek.



MAP 11. EROSION POTENTIAL IN THE WATERSHED AREA

Sediments from road surfaces can be seen in Nannie and Rock Creeks. In Rock Creek, these sediments are transported downstream though the system annually. In the Nannie Creek watershed, the drainage network is limited, and sediment caused by natural erosion and management activities directly enters the main channel. Nannie Creek has a small basin for the collection of precipitation, limiting its flow and ability to transport sediments downstream. Historically, Nannie Creek probably had a sensitively balanced sediment transport system that moved the natural loading of sediment from debris slides and raveling to the alluvial fan below. In its present state, collections of soil and road aggregates can be seen throughout the entire stream. The majority of sediment is not natural, but rather caused by roads and harvest units positioned too closely to the stream. The equilibrium of this system no longer exists, with the capacity for sediment transport being exceeded by the rate of sedimentation.

Management activities do not appear to be causing increased sedimentation in Cherry Creek above the diversion. There are no roads in close proximity to the creek in this area nor any road crossings. Below the diversion, there are multiple causes of sedimentation, as discussed under Issue F.

Summary:

Areas which have fine soil textures, lower infiltration rates, reduced vegetative cover, and/or high amounts of compaction are at risk for erosion. Currently, the greatest input of sediment to the creeks appears to be caused by roads. Roads channel sediments into both Rock Creek and Nannie Creek annually. Sediments in Rock Creek are transported downstream annually. Aggradation is occurring in Nannie Creek, where lower flows limit transport of sediments.

DESIRED FUTURE CONDITION

The potential for erosional processes to occur has been lessened. This has been accomplished by reducing the amount currently compacted surfaces, limiting activities which cause soil compaction reducing soil disturbance during timber harvest, improving surface water control on roads, and implementing Best Management Practices. A reduction in the amount of compacted surface has been attained by decommissioning roads, especially those within 200' of the streams; sub-soiling previously compacted harvest units before reforestation; and preventing additional compaction by restricting the use of heavy equipment to periods when soil moisture is less than 17% (based on recent monitoring conducted on the District).

VI. MANAGEMENT RECOMMENDATIONS AND RESTORATION OPPORTUNITIES

This chapter focuses on management, restoration, and information needed to achieve desired future conditions listed under Issues A-H. Only general recommendations are given when detailed management will be developed in other documents following this report, or existing information is not sufficient to make more specific recommendations. For the most part, standards and guidelines listed in the Winema Forest Plan and President's Forest Plan are not repeated here.

A. Upland Forests

Manage red fir stands to reduce the potential for future forest health problems and stand-replacing fires and to promote development of late seral conditions in the Late Successional Reserve. Manage white fir mixed conifer stands to: reduce mortality from insects and disease; reduce fuel loads and the potential for stand-replacing fires; promote development of late successional conditions in the LSR; and promote retention and recruitment of early seral tree species in bald eagle habitat and outside of the LSR. In all zones, consider allowing natural fires to burn or reintroducing fire, where feasible and not in conflict with desired future conditions. Limit soil disturbance during management activities. Prevent spread of noxious weeds and control existing weed populations.

Details for management will be developed in subsequent fire management plans, an LSR plan, and proposed treatments for the Nannie-Rock Planning Area. The Noxious Weed Environmental Assessment for the Winema National Forest addresses noxious weed prevention and control.

Information Needs:

1. Survey for non-vascular plants, fungi, and invertebrates per the President's Forest Plan.

2. Further investigate the effects of forest succession on the hydrograph.

B. Low Elevation Wetlands

The team does not have adequate information or resources to make recommendations for restoring wetlands on the Cherry Creek glacial outwash fan and adjoining areas. Because of the significant changes in hydrology and species composition, reversing impacts of past management would require considerable study and money and may not be possible in some cases (e.g., eradicating well-established exotic species). In addition, the majority of low elevation wetlands occur on private land, or are influenced by conditions on private land, where restoration efforts would likely conflict with current uses.

On a smaller scale, a restoration opportunity exists in Section 13 to improve a moist meadow on NFS land. This area has been compacted by unauthorized cattle use and contains many weedy species. Subsoiling and seeding with native species is recommended.

Information Needs:

1. The team recommends analyzing and addressing restoration of these areas in the Klamath River Basin analysis, and exploring possibilities for cooperative projects with private land owners.

C. Fish/Aquatic Habitat

Install fish screens on the diversion in Cherry Creek to prevent fish from entering the diversion canals.

Re-introduce large woody debris into the lower reaches of Rock (R2 and R1) and Cherry Creeks (R5 and R6).

Remove brook trout from Rock and Cherry Creeks.

Restore channel function to Penn Creek so that an intermittent connection is maintained between Penn and Rock Creeks. The objectives of this are to (1) expand seasonal fish habitat, and (2) introduce gravels currently retained in Penn Creek into Rock Creek, where suitable spawning substrates are limited.

Information Needs:

1. Repeat level II stream inventory surveys on Rock and Cherry Creeks. Complete intermittent stream surveys on Nannie and Penn Creeks. Establish a spawning habitat survey for Rock and Cherry Creeks.

2. Further investigate the status of bull trout in Cherry Creek.

3. Further investigate the potential for fish migration along the connections of Cherry and Nannie Creeks to Upper Klamath Lake. Identify dikes, dams, diversions, and inflows from other sources.

4. Investigate the feasibility of restoring the connection between Cherry Creek and Upper Klamath Lake. Issues such as maintaining in-stream flows year-round and providing passage for exotic fish to enter Cherry Creek from the lake need to be examined.

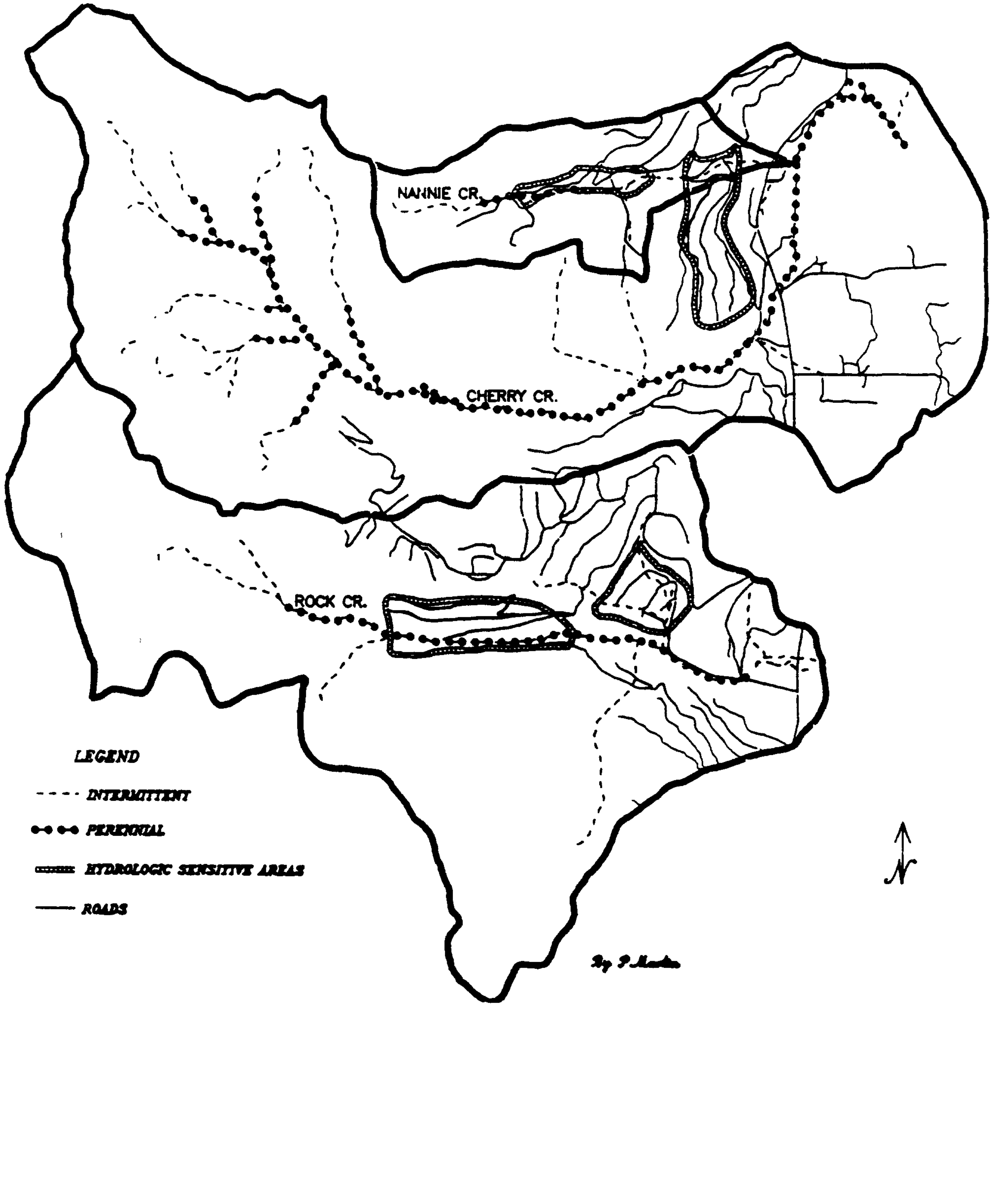
5. Establish a monitoring program for fish.

6. Establish a monitoring program to identify amphibian and macroinvertebrate habitat and presence.

D. Roads and Channel Morphology

Limit construction of new roads and obliterate or improve existing roads within .25 miles of the streams and the hydrologically sensitive areas shown on Map 12. Achieve a 50% reduction in road density within these areas. Hydrologically sensitive areas are most likely to contribute to changes in the hydrograph caused by high road density and proximity to a stream channel. Roads that increase the drainage network or impact the morphology of the streams or their tributaries should be the highest priority for obliteration or improvement.

Rock Creek: In Sections 3 and 4, Forest Road 3419-060 is limiting development of a riparian zone and woody debris recruitment along Rock Creek. The lack of vegetation and presence of road fill along the banks inhibits adjustment of the stream. The upper end of Forest Road 3419-060, along with the 063, 065, 090, and 310 spurs, have greatly impacted the morphology and functioning of Penn Creek. In Section 31, the end of Forest Road 3419-360 has cut into the ground water flow. Restoration opportunities include reconstructing the Penn Creek Channel, introducing large woody debris into Rock Creek in Sections 3 and 4, closing and ripping the identified spur roads, and planting unvegetated areas.



MAP 12. HYDROLOGICALLY SENSITIVE AREAS

Cherry Creek: The lower portion of Cherry Creek in Section 14 has been modified by channelization. The stream has down cut, creating tall, bare, vertical banks, and is now side cutting into the banks. A spur off the 600 spur road runs adjacent to the stream in several places. Further monitoring and analysis are needed to determine restoration opportunities in this area.

Nannie Creek: Forest Roads 3484 and 3484-490 are contributing to sediment loading and quick flow runoff into Nannie Creek in Sections 8 and 17. Poor culvert positioning at the 3484 crossing has caused scouring below and ponding above the culvert. Two small roads in close proximity to the stream appear to be unnecessary and may be contributing to sedimentation: a skid trail off the 3484-338 spur in Section 16 runs adjacent and parallel to the creek; in Section 10, an unmapped road extends north from the 185 spur and crosses the creek. Restoration could include closing and ripping the identified roads, planting ripped areas, and removing the culvert on the 3484 road; or closing the smaller roads, waterbarring the 3484 road, and replacing the culvert. The team also noted that increasing the frequency of road maintenance on the 3484 road and trailhead parking area could decrease rilling and washboarding and improve safety for recreationists pulling horse trailers. This is also true of Forest Road 3450 and the Cherry Creek Trailhead parking area.

Information Needs:

1. Prior to reconstruction of the Penn Creek channel, monitor flow distribution in disturbed areas. This will include visual identification of disruption of flow due to past heavy equipment operation in the channel and the location of spur roads. Identify areas where flow leaves the channel and is dispersed into units.

2. In conjunction with introduction of large wood into Rock Creek, monitor to assess its effectiveness in creating desired channel conditions. Prior to introduction of wood, establish sample cross sections using rod and level surveying. Record baseline channel geometry and water velocities and conduct Wolman pebble counts for identification of particle size. After wood placement, use follow-up monitoring at the established sites to assess scour and fill processes.

3. Continue long-term monitoring of flows in Cherry Creek above the diversion. The relatively undisturbed conditions of the watershed will make it useful as a reference for comparison with other watersheds.

4. Monitor the migration of Cherry Creek below the diversion to provide information to assess the potential for restoration. Establish permanent cross sections at point bar locations, using rod and level surveying. Track development of point bar and flood plain formation, as well as the amount of scour at outside bends. Place rebar erosion pins at various sites along the banks to assess the rates of erosion.

5. Monitor the effects of heavy equipment operation in Cherry Creek near the diversion. Establish permanent photo points to track changes in channel geometry.

6. Monitor the sources of sediment entering Nannie Creek. Better quantify the location and distribution of landslides in the Nannie drainage with additional aerial photo work and field investigation. Assess the channel stability rating using existing protocol. Take depth and width measurements of gullies and rills on roads, skid trails, and harvest units in areas adjacent to the stream channel.

7. Conduct an assessment of the effects of road management objectives (RMO's) on hydrology.

E. Trails

Improve wilderness trail design to prevent channeling of water, routing of water into lakes, and blockage of side channel flow. Consult with the District soils specialist when designing new trails and crossings, or relocating trails. Several trails located throughout the watershed area were observed to channel water during rainstorms. Routing of water into lakes has not been monitored, but may be occurring. The Cherry Creek Trail crosses several perennial and intermittent side channels. Some of the crossings are blocking and diverting flow of water. At the second crossing of the mainstem, the Cherry Creek Trail does not provide for adequate horse crossing, and bank erosion is occurring.

Information Needs:

1. Additional investigation and monitoring are needed to locate problem areas, identify restoration opportunities, and determine the need to revise existing trail standards.

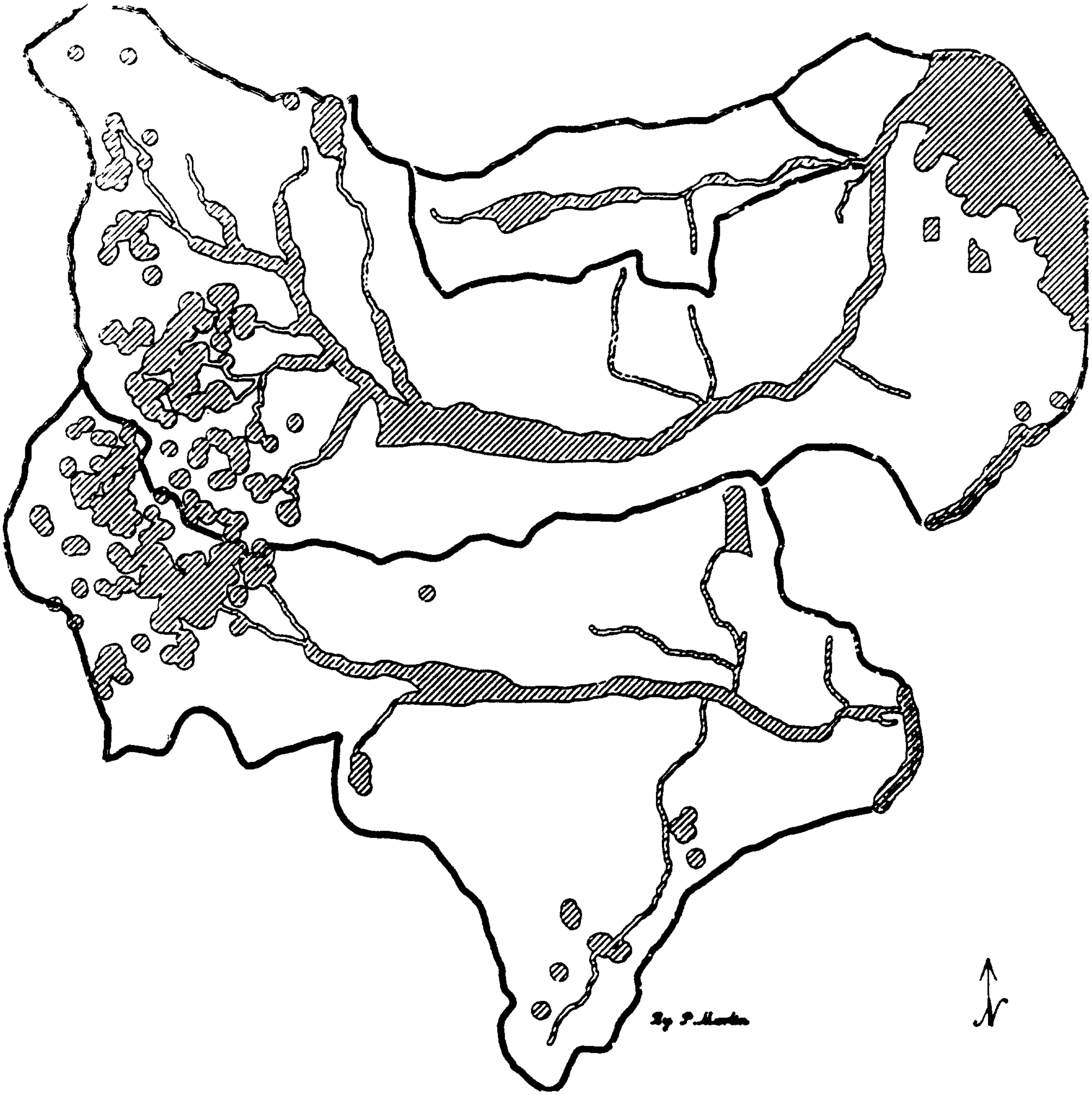
F. Riparian Reserves

Recommendations for riparian reserves are shown on Map 13. Reserves total 5,738 acres. **Reserve locations have been scanned into GIS and should be referenced during planning of any project in the watershed area.** In general, the team recommends following the standards and guidelines listed in the President's Forest Plan for lake (300'), wetland (150'), seasonally flowing or intermittent stream (100'), and perennial stream (300') riparian reserves. Modifications are listed below.

Rock: In Sections 6, 31, and 32, the reserve has been expanded beyond 300' to include the numerous small springs and seeps in this area.

Cherry: The riparian reserve was expanded to include most of the valley bottom in Sections 19, 20, 28, 29, and 30. This decision was based on the large number of springs present in this area, extension of riparian vegetation in the moist valley bottom, and importance of the area to wildlife.

Nannie: The riparian reserve in Sections 8 and 17 was expanded to include all of the lodgepole pine basin. Several springs arise in this area during the spring and early summer. In Section 9 (SE corner), the riparian reserve was extended beyond 100' to Forest Road 3484. The intent of this was to provide a buffer between the road and the creek. In Section 10, the reserve was similarly increased to form a buffer between the creek and Forest Road 3484-060. This area also includes a spring.



MAP 13. RIPARIAN RESERVES

G. Geomorphological Reserves

The team recommends applying the timber standards and guidelines given in the Winema Forest Plan for Riparian Areas Adjacent to Class IV Streams to ephemeral drainages not meeting the definition of seasonally-flowing or intermittent streams in the President's Forest Plan. Although riparian vegetation is usually lacking in these areas, maintaining unimpeded water flow during high runoff periods is important for hydrologic functioning. On steeper slopes, ephemeral drainages are susceptible to debris flows and landslides during extreme runoff events. Standards and guidelines apply to 25' on either side of ephemeral drainages and include the following:

1. Activity-created debris shall be cleared from stream channels except for large woody material keyed into stream banks.

2. Skid trails shall cross only at approved locations perpendicular to the stream and shall be designed to avoid altering the drainage characteristics.

Information Needs:

1. **The locations of geomorphological reserves are not mapped, and will need to be determined by field reconnaissance during project planning.**

H. Soils

Identify skid trails, roads, and landings which are no longer needed and subsoil them to alleviate compaction, particularly in the Rock and Nannie drainages, where the percent of area compacted outside the wilderness exceeds Forest Plan recommendations that no more than 20% of an area have detrimental soil conditions.

To prevent future soil compaction, the team recommends setting the allowable soil moisture restriction for heavy equipment use to 17%. This is the level recent monitoring data suggests is needed to prevent a 20% increase in soil bulk density and meet Forest Plan standard and guideline 12-5.

Information Needs:

1) Further investigate the effects of compaction on hydrology, erosion, and site productivity.

2) Monitor the recovery of past landslides in all three drainages to determine revegetation rates and the potential for restoration. Identify areas where movement into streams is occurring.

3) Additional soil typing and mapping are needed to expand upon and better define the information in the Winema Soil Resource Inventory (Carlson, 1979).

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Appendix A. List of People Consulted

Core Team	
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Brent Frazier	Wildlife Biologist
Darryl Gowan	Fish Biologist
Rick Hardy	Wildlife Biologist
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Amy Krommes	Silviculturist
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Roberto Morganti	Landscape Architect
Jeanie Sheehan	Reviewing Editor
Chris Thompson	Archeologist

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Tom Neal	Engineer
Rob Shull	District Ranger
Marv Stump	Land and Minerals
Charlie Thompson	Forestry Technician

Public/Other Agencies	
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Dan Brown	Circle DE Lumber
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Gail Danforth	Cherry Creek Resident
Garwin Carlson	Retired Soil Scientist
Art Eggelston	Rocky Point Resident
John Fortune	Fish Biologist, Oregon Dept. of Fish and Wildlife
Jack Inman	Retired Wildlife Biologist
Jake Kahn	Biologist, Klamath Tribes
John Lund	Professor of Geology, Oregon Institute of Technology
Ralph Opp	Wildlife Biologist, Oregon Dept. of Fish and Wildlife
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Denny Rickards	Rocky Point Resort
Joe Riker	Amateur Mycologist/City of Klamath Falls
Jim Rust	Contractor
Tom Whittemore	Klamath Country Flycasters

Appendix B. Wildlife Species Documented or with Potential Habitat in the Watershed Area

Common Name	Scientific Name	Status	Habitat Associated With		
			Late Seral	P.Pine	Wetlands
AMPHIBIANS					
Long-toed Salamander	*Ambystoma macrodactylum*				
Roughskin Newt	*Taricha granulosa*		X		
Oregon Slender Salamander	*Batrachoseps wrighti*	Oc	X		
Western Toad	*Bufo boreas*				
Pacific Treefrog	*Pseudacris regilla*				
Tailed Frog	*Ascaphus truei*		X		
Cascade Frog	*Rana cascadai*	Oc, Fc			
Bullfrog	*Rana catesbeiana*				X
Spotted Frog	*Rana pretiosa*	Oc, Fc			X
REPTILES					
Western Pond Turtle	*Clemmys marmorata*	S, Oc, Fp			X
Western Fence Lizard	*Sceloporus occidentalis*				
Short-horned Lizard	*Phrynosoma douglassi*			X	
Western Skink	*Eumeces skiltonianus*				
Northern Alligator Lizard	*Elgaria coeruleas*				
Rubber Boa	*Charina bottae*				
Ringneck Snake	*Diadophis punctatus*				X
Gopher Snake	*Pituophis melanoleucus*				
W. Terr.(Klamath) Garter Sn	*Thamnophis elegans*				X
Common Garter Snake	*Thamnophis sirtalis*				X
MAMMALS					
Virginia Opossum	*Didelphis virginiana*				
Marsh Shrew	*Sorex bendirii*				X
Pacific Shrew	*Sorex pacificus*		X		X
Water Shrew	*Sorex palustris*				
Trowbridge's Shrew	*Sorex trowbridgii*		X		
Vagrant Shrew	*Sorex vagrans*				X
Shrew-mole	*Neurotrichus gibbsii*		X		X
Coast Mole	*Scapanus orarius*				
Hoary Bat	*Lasiurus cinereus*		X		
Pallid Bat	*Antrozous pallidus*	Ov			
Big Brown Bat	*Eptesicus fuscus*		X		
Townsend's Big-eared Bat	*Plecotus townsendii*	S, Oc, Fc			
Silver-haired Bat	*Lasionycteris noctivagans*		X		
Little Brown Myotis	*Myotis lucifugus*		X		
Fringed Myotis	*Myotis thysanodes*	Ov	X		
Long-legged Myotis	*Myotis volans*		X		
Yuma Myotis	*Myotis yumanensis*		X		
Long-eared Myotis	*Myotis evotis*		X		
California Myotis	*Myotis californicus*		X		
Western Small-footed Myotis	*Myotis ciliolabrum*		X		
American Pika	*Ochotona princeps*				
Mountain Cottontail	*Sylvilagus nuttallii*				
Snowshoe Hare	*Lepus americanus*				
Yellow-pine Chipmunk	*Tamias amoenus*				
Yellow-bellied Marmot	*Marmota flaviventris*				
Golden-Mantled Squirrel	*Spermophilus lateralis*				
Douglas Squirrel	*Tamiasciurus douglasii*		X		
Northern Flying Squirrel	*Glaucomys sabrinus*		X		
Botta's Pocket Gopher	*Thomomys bottae*				
Western Pocket Gopher	*Thomomys mazama*				
Northern Pocket Gopher	*Thomomys talpoides*				
American Beaver	*Castor canadensis*				X
Western Harvest Mouse	*Reithrodontomys megalotis*				
Deer Mouse	*Peromyscus maniculatus*		X		
Bushy-tailed Woodrat	*Neotoma cinera*		X		
Dusky-footed Woodrat	*Neotoma fuscipes*		X		
Western Red-backed Vole	*Clethrionomys californicus*		X		
Heather Vole	*Phenacomys intermedius*				
Long-tailed Vole	*Microtus longicaudus*				X
Montane Vole	*Microtus montanus*				X

Common Name	Scientific Name	Status	Habitat Associated with Late Seral	P Pine	Wetlands
Water Vole	*Microtus richardsoni*				
Common Muskrat	*Ondatra zibethicus*				X
Western Jumping Mouse	*Zapus princeps*				X
Pacific Jumping Mouse	*Zapus trinotatus*				X
Common Porcupine	*Erethizon dorsatum*				
Coyote	*Canis latrans*				
Red Fox	*Vulpes vulpes*				
Common Gray Fox	*Urocyon cinereoargenteus*				
Black Bear	*Ursus americanus*		X		
Raccoon	*Procyon lotor*				X
American Marten	*Martes americana*	Ov	X		
Fisher	*Martes pennanti*	Oc, Fc	X		
Ermine	*Mustela erminea*	F			
Long-tailed Weasel	*Mustela frenata*				
Mink	*Mustela vison*	F			X
California Wolverine	*Gulo gulo*	S, Ot, Fc			
American Badger	*Taxidea taxus*	F			
Striped Skunk	*Mephitis mephitis*	F			X
Northern River Otter	*Lutra canadensis*	F			X
Mountain Lion	*Felis concolor*	G			
North American Lynx	*Lynx (Felis) lynx*	S, Fc	X		
Bobcat	*Lynx rufus*	F			
Elk	*Cervus elaphus*	G	X		
Mule Deer	*Odocoileus hemionus*	G			
BIRDS					
Common Loon	*Gavia immer*	M			
Pied-billed grebe	*Podilymbus podiceps*				
Horned Grebe	*Podiceps auritus*	Op			
Red-necked Grebe	*Podiceps grisegena*	Oc			
Eared Grebe	*Podiceps nigricollis*				
American Bittern	*Botaurus lentiginosus*				X
Great Blue Heron	*Ardea herodias*		X*		X
Great Egret	*Casmerodius albus*				X
Snowy Egret	*Egretta thula*	Ov			X
Black-crowned Night Heron	*Nycticorax nycticorax*				X
Green-backed Heron	*Butorides striatus*				X
Greater Sandhill Crane	*Grus canadensis*	Ov			X
Tundra Swan	*Cygnus columbianus*				X
White-fronted Geese	*Anser albitrons*				X
Snow Goose	*Chen caerulescens*				X
Ross' Goose	*Chen rossii*				X
Canada Goose	*Branta canadensis*				X
Wood Duck	*Aix sponsa*	M			X
Green-winged Teal	*Anas crecca*				X
Mallard	*Anas platyrhynchos*				X
Northern pintail	*Anas acuta*	M			X
Blue-winged Teal	*Anas discors*	M			X
Cinnamon Teal	*Anas cyanoptera*				X
Northern Shoveler	*Anas clypeata*	M			X
Gadwall	*Anas strepera*				X
American Wigeon	*Anas americana*				X
Canvasback	*Aythya valisineria*	M			X
Redhead	*Aythyra americana*				X
Ring-necked Duck	*Aythyra collaris*				X
Lesser Scaup	*Aythyra affinis*				X
Common Goldeneye	*Bucephala clangula*		X?		X
Barrow's Goldeneye	*Bucephala islandica*	Op	X?		X
Bufflehead	*Bucephala albeola*	Op	X		X
Hooded Merganser	*Lophodytes cucullatus*				X
Common Merganser	*Mergus merganser*				X
Ruddy Duck	*Oxyura jamaicensis*				X
Yellow Rail	*Coturnicops noveboracensis*	Oc			X
Virginia Rail	*Rallus limicola*				X
Sora	*Porzana carolina*				X
American Coot	*Fulica americana*				X
Killdeer	*Charadrius vociferus*				X
Greater Yellowlegs	*Tringa melanoleuca*				X

Common Name	Scientific Name	Status	Habitat Associated With Late Seral	P Pine	Wetlands
Willet	Catoptrophorus semipalmatus				X
Long-billed Curlew	Numenius americanus				X
Western Sandpiper	Calidris mauri				
Spotted Sandpiper	Actitis macularia				
Long-billed Dowitcher	Lomnodermuis scolopaceus				X
Common Snipe	Galinago gallinago				X
Wilson's Phalarope	Phalaropus tricolor				X
Franklin's Gull	Larus pipixcan	Op			X
Ring-billed Gull	Larus californicus				X
California Gull	Larus californicus				X
Caspian Tern	Sterna caspia				X
Forster's Tern	Sterna forsteri				X
Black Tern	Chlidonias nigar				X
Turkey Vulture	Cathartes aura	N			
Golden Eagle	Aquila chrysaetos				
Bald Eagle	Haliaeetus leucocephalus	Pt	X*	X	
Northern Harrier	Circus cyaneus	N			X
Sharp-shinned Hawk	Accipiter striatus	N			
Cooper's Hawk	Accipiter cooperii	N			
Northern Goshawk	Accipiter gentilis	Oc	X	X	
Swainson's Hawk	Buteo swainsoni	Ov		X	
Red-tailed Hawk	Buteo jamaicensis	N	X*		
Rough-legged Hawk	Buteo lagopus				
Osprey	Pandion haliaetus	N	X*		
American Kestrel	Falco sparverius	N	X*		
Merlin	Falco columbaris	N	X		
Prairie Falcon	Falco mexicanus				
Blue Grouse	Dendragapus obscurus				
California Quail	Callipepla californica				
Mountain Quail	Oreortyx pictus				
Mourning Dove	Zenaida macroura			X	
Barn Owl	Tyto albo				
Flammulated Owl	Otus flammeolus	Oc, N	X	X	
Western Screech Owl	Otus kennicottii		X*		
Great Horned Owl	Bubo virginianus		X*		
Northern Pygmy Owl	Glaucidium gnoma	Ou	X		
Spotted Owl	Strix occidentalis	Pt	X	X	
Barred Owl	Strix varia		X		
Great Gray Owl	Strix nebulosa	Ov	X		
Long-eared Owl	Asio otus	N			
Short-eared Owl	Asio flammeus	N			X
Boreal Owl	Aegolius funereus				
Northern Saw-whet Owl	Aegolius acadicus				
Common Nighthawk	Chordeiles minor	N			
Common Poorwill	Phalaenoptilus nuttallii	N			
Vaux's Swift	Aeronautes saxatalis	N	X		
White-throated Swift	Aeronautes saxatalis	N			
Black-chinned Hummingbird	Archilochus alexandri	N			
Anna's Hummingbird	Calypte anna	N			
Calliope Hummingbird	Stellula calliope	N			
Rufous Hummingbird	Selasphorus rufus	N			
Belted Kingfisher	Ceryle alcyon	N			
Lewis' Woodpecker	Melanerpes lewis	Oc	X*	X	
Yellow-bellied Sapsucker	Sphyrapicus various		X*		
Red-naped Sapsucker	Sphyrapicus nuchalis		X*		
Red-breasted Sapsucker	Sphyrapicus ruber		X*		
Williamson's Sapsucker	Sphyrapicus thyroideus	Ou, N	X*	X	
Downy Woodpecker	Picoides pubescens				X
Hairy Woodpecker	Picoides villosus		X		
White-headed Woodpecker	Picoides albolarvatus	Oc	X*	X	
Three-toed Woodpecker	Picoides tridactylus	Oc	X		
Black-backed Woodpecker	Picoides arcticus	Oc	X		
Northern Flicker	Colaptes auratus		X*	X	
Pileated Woodpecker	Dryocopus pileatus	Oc	X	X	
Western Kingbird	Tyrannus verticalis	N			
Olive-sided Flycatcher	Contopus borealis	N	X*		
Western Wood-Peewee	Contopus sordidulus	N			
Willow Flycatcher	Empidonax traillii	N			X

Common Name	Scientific Name	Status	Habitat Associated with Late Seral	P Pine	Wetland
Hammond's Flycatcher	Empidonax hammondii	N	X		
Dusky Flycatcher	Empidonax oberholseri	N			
Gray Flycatcher	Empidonax wrightii	N			
Ash-throated Flycatcher	Myiarchus cinerascens	N			X
Horned Lark	Eremophila alpestris				
Purple Martin	Progne subis	Oc, N			X
Tree Swallow	Tachycineta bicolor	N	X*		X
Violet-green Swallow	Tachycineta thalassina	N			X
N Rough-winged Swallow	Stelgidopteryx serripennis	N			
Bank Swallow	Riparia riparia	Ou, N			
Cliff Swallow	Hirundo pyrrhonota	N			
Barn Swallow	Hirundo rustica	N			
Gray Jay	Perisoreus canadensis				
Steller's Jay	Cyanocitta stelleri				
Scrub Jay	Aphelocoma coerulescens				
Clark's Nutcracker	Nucifraga columbiana				
Black-billed Magpie	Pica pica			X	
American Crow	Corvus brachyrhynchos				
Common Raven	Corvus corax				
Wrentit	Chamaea fasciata				
Black-capped Chickadee	Parus atricapillus				
Mountain Chickadee	Parus gambeli				
Chestnut-backed Chickadee	Parus rufescens		X		
Plain Titmouse	Parus inornatus				
Bushtit	Psaltriparus minimus				
Red-breasted Nuthatch	Sitta canadensis		X		
White-breasted Nuthatch	Sitta carolinersis		X*		
Pygmy Nuthatch	Sitta pygmaea	Ov	X*		
Brown Creeper	Certhia americana		X		
Bewick's Wren	Thryomanes bewickii			X	
House Wren	Troglodytes aedon	N			
Winter Wren	Troglodytes troglodytes		X		
Marsh Wren	Cistothorus palustris	N			X
Golden-crowned Kinglet	Regulus satrapa		X		
Ruby-crowned Kinglet	Regulus calendula	N	X		
Blue-gray Gnatcatcher	Polioptila caerulea	N			X
Western Bluebird	Sialia mexicana	Ov		X	
Mountain Bluebird	Sialia currucoides	N			
Townsend's Solitaire	Myadestes townsendi				
Swainson's Thrush	Catharus ustulatus	N			
Hermit Thrush	Catharus guttatus	N	X		
Varied Thrush	Ixoreus naevius		X		
American Robin	Turdus migratorius	N			
Northern Shrike	Lanius execubitor				
Northern Mockingbird	Mimus polyglottos			X	
Water Pipit	Anthus rubescens	N			
American Dipper	Cinclus mexicanus				
Bohemian Waxwing	Bombycilla garrulus				
Cedar Waxwing	Bombycilla cedrorum	N			
European Starling	Sturnus vulgaris	N			
Solitary Vireo	Vireo solitarius	N			
Warbling Vireo	Vireo gilvus	N	X		X
Orange-crowned Warbler	Vermivora celata	N			
Nashville Warbler	Vermivora ruficapilla	N			
Yellow Warbler	Dendroica petechia	N			X
Yellow-rumped Warbler	Dendroica coronata	N			
Black-throated Gray Warbler	Dendroica nigrescens	N		X	
Townsend's Warbler	Dendroica townsendii	N	X		
Hermit Warbler	Dendroica occidentalis	N	X		
MacGillivray's Warbler	Oporornis tolmiei	N			
Common Yellowthroat	Geothlpis trichas	N			X
Wilson's Warbler	Wilsonia pusilla	N	X		X
Black-headed Grosbeak	Pheucticus lelanocephalus	N			X
Lazuli Bunting	Passerina amoena	N			X
Green-tailed Towhee	Pipilo chlorurus	N		X	
Rufous-sided Towhee	Pipilo erythrophthalmus				X
American Tree Sparrow	Spizella arborea				X
Chipping Sparrow	Spizella passerina	N			

Common Name	Scientific Name	Status	Habitat Associated With: Late Seral	P Pine	Wetlands
Brewer's Sparrow	Spizella breweri	N			
Vesper Sparrow	Pooecetes gramineus	N			
Lark Sparrow	Chondestes grammacus	N			
Savannah Sparrow	Passerculus sandwichensis	N			X
Fox Sparrow	Passerella iliaca				X
Song Sparrow	Melospiza melodia				X
Lincoln's Sparrow	Melospiza lincolnii	N			X
Golden-crowned Sparrow	Zonotrichia atricapilla				X
White-crowned Sparrow	Zonotrichia leucophrys	N			
Dark-eyed Junco	Junco hyemalis				
Western Meadowlark	Sturnella neglecta				
Red-winged Blackbird	Agelaius phoeniceus				X
Tricolored Blackbird	Agelaius tricolor				X
Yellow-headed Blackbird	Xanthocephalus xanthocephalus	N			X
Brewer's Blackbird	Euphagus cyanocephalus	N			X
Brown-headed Cowbird	Molothrus ater	N			
Northern Oriole	Icterus galbula	N			X
Western Tanager	Piranga ludoviciana	N	X*		
House Sparrow	Passer domesticus				
Pine Siskin	Carduelis pinus				
Lesser Goldfinch	Carduelis psaltria				X
American Goldfinch	Carduelis tristis				X
Red Crossbill	Loxia curvirostra		X		
Rosy Finch	Leucosticte arctoa				
Purple Finch	Carpodacus cassinii				
Cassin's Finch	Carpodacus cassinii	N	X*		
House Finch	Carpodacus mexicanus				
Evening Grosbeak	Coccothraustes vespertinus				

Habitats:

Use of late seral, ponderosa pine, or wetland habitats by a species is indicated by an X. Species associated with late seral habitats are taken from the SAT report with additions from other references. The list includes those with primary breeding, feeding, or resting habitat in late or mid-to-late seral stands with >55% canopy closure. Species which occur in other habitats, but are most abundant in late seral stands, are also included. Species marked with an asterisk use large trees or snags for breeding or feeding, but prefer stands with more open canopies than typically associated with late seral stands, or use stands with variable canopies.

Species associated with ponderosa pine include those most likely to occur in relatively open ponderosa pine-dominated mixed conifer stands and species which prefer the ponderosa pine, Douglas-fir, sugar pine component of white fir-dominated mixed conifer stands for nesting or feeding.

Species associated with wetlands include those with suitable habitat in the swamps, marsh, wet meadows, vernally wet meadows, willow thickets and aspen/cottonwood groves found at lower elevations in the watershed area. Some species may also use similar habitats, where present, at higher elevations.

Status Codes:

Fe = Federal endangered, Ft = Federal threatened, Fc = Federal C2 Candidate, Fp = Federal proposed, S = R6 sensitive, Oe = Oregon endangered, Oc = Oregon critical, Ov = Oregon vulnerable, Op = peripheral or naturally rare, Ou = Oregon undetermined status, G = game animal, F = furbearer, N = neotropical migrant, M = migrant

Nomenclature follows Puchy and Marshall (1993).

APPENDIX C Plant and Fungi Species Documented or Expected to Occur in the Watershed Area

	Status	Habitat Associated With Late Seral	P.Pine	Wetland
LOWER VASCULAR PLANTS				
EQUISETACEAE				
Equisetum arvense				X
ISOETACEAE				
Isoetes echinospora				
POLYPODIACEAE				
Athyrium filix-femina				
Cheilanthes gracillima				
Cryptogramma crispa				
Cystopteris fragilis				
Polystichum munitum		X		
Pteridium aquilinum				
GYMNOSPERMS				
CUPRESSACEAE				
Calocedrus decurrens			X	
Juniperus communis				
PINACEAE				
Abies concolor				
Abies lasiocarpa				
Abies magnifica var. shastensis				
Picea engelmannii				X
Pinus albicaulis				
Pinus contorta				X
Pinus lambertiana			X	
Pinus monticola				
Pinus ponderosa			X	
Pseudotsuga menziesii			X	
Tsuga mertensiana				
TAXACEAE				
Taxus brevifolia	SP	X		
ANGIOSPERMS-MONOCOTS				
ALISMATACEAE				
Sagittaria latifolia *				X
CYPERACEAE				
Carex amphifolia				X
Carex athrostachya				X
Carex buxbaumii				
Carex deweyana				
Carex lenticularis				
Carex mertensii				
Carex microptera				
Carex multicostata				
Carex pachystachya				X
Carex pensylvanica				
Carex praegracilis *				X
Carex rossii				
Carex rostrata				X
Carex sitchensis				
Carex subfusca				
Eleocharis bella				X
Eleocharis palustris				X
Eleocharis pauciflora *				X
Scirpus acutus *				X
Scirpus congdonii				
Scirpus microcarpus				

	Status	Habitat Associated With Late Seral	P.Pine	Wetland
IRIDACEAE				
Iris missouriensis				X
Sisyrinchium angustifolium				X
JUNCACEAE				
Juncus balticus				X
Juncus drummondii				
Juncus hemiendytus				
Juncus nevadensis				X
Juncus parryi				
Juncus supiniformis				
Luzula hitchcockii				
Luzula parviflora				
LILIACEAE				
Brodiaea congesta				X
Camassia quamash				X
Clintonia uniflora		X		
Lilium pardalinum				
Smilicina racemosa		X		
Smilicina stellata		X		
Streptopus amplexifolius		X		
Streptopus roseus		X		
Tofieldia glutinosa				X
Trillium ovatum		X		
Zigadenus venenosus				X
Veratrum viride				
NAJADACEAE				
Najas guadalupensis *				X
ORCHIDACEAE				
Calypso bulbosa		X		
Corallorhiza mertensiana		X		
Goodyera oblongifolia		X		
Habenaria dilatata				X
Habenaria saccata		X		
Listera cordata		X		
Spiranthes romanzoffiana				X
POACEAE				
Agrostis exarata				X
Agrostis idahoensis				
Agrostis semiverticillata	I			
Agrostis thurberiana				
Aplopecurus pratensis	I			X
Bromus carinatus				
Bromus commutatus	I			
Bromus japonicus	I			
Bromus orcuttianus				
Bromus suksdorfii				
Bromus tectorum	I			
Calamagrostis canadensis				
Calamagrostis inexpansa				
Calamagrostis neglecta				
Dactylus glomerata	I			
Danthonia californica				
Danthonia intermedia				
Danthonia spicata			X	
Deschampsia caespitosa				X
Deschampsia danthonioides				
Elymus glaucus				
Festuca idahoensis			X	
Festuca microstachys				
Glyceria borealis *				X
Glyceria elata				
Melica harfordii				
Melica smithii				
Phalaris arundinacea *	I			X
Phleum alpinum				X
Phleum pratense	I			X

	Status	Habitat Associated With: Late Seral	P.Pine	Wetland
Poa nervosa				
Poa pratensis	I			X
Poa sandbergii				
Poa secunda				
Puccinellia pauciflora				
Sitanion hystrix				
Stipa lettermanii			X	
Stipa occidentalis			X	
Stipa thurberiana			X	
Trisetum canescens			X	
Trisetum spicatum				
POTAMOGETONACEAE				
Potamogeton gramineus				
Potamogeton natans				
SPARGANIACEAE				
Sparganium angustifolium				X
TYPHACEAE				
Typha latifolia *				X
ANGIOSPERMS-DICOTS				
ACERACEAE				
Acer circinatum				
APIACEAE				
Angelica arguta				
Angelica canbyi				
Cicuta douglasii				X
Heracleum lanatum				X
Liguisticum grayi				X
Lomatium triternatum			X	
Osmorhiza chilensis				
Osmorhiza occidentalis				
Perideridia gairdneri				X
Perideridia oregana				X
Sium suave *				X
Sphenosciadium capitellatum				X
APOCYNACEAE				
Apocynum androsaemifolium				
ASTERACEAE				
Achillea millefolium				
Adenocaulon bicolor		X		
Agoseris aurantiaca				
Agoseris glauca			X	
Agoseris heterophylla				
Anaphalis margaritacea				
Antennaria alpina				
Antennaria luzuloides			X	
Antennaria microphylla			X	
Antennaria stenophylla				
Antennaria umbrinella			X	
Arnica chamissonis *				X
Arnica cordifolia				
Arnica discoidea			X	
Artemisia ludoviciana			X	
Aster alpigenus				
Aster foliaceus				
Aster ledophyllus				
Aster modestus				X
Aster occidentalis				
Blepharipappus scaber			X	
Cirsium arvense	NW			
Cirsium vulgare	I			
Crepsis acuminata				
Erigeron peregrinus				
Erigeron ursinus				
Eriophyllum lanatum			X	

	Status	Habitat Associated With: Late Seral	P Pine	Wetland
Eupatorium occidentale				
Gnaphalium palustre				X
Haplopappus bloomeri			X	
Haplopappus greenei				
Hemizonia pungens	I			
Hieraceum albertinum			X	
Hieraceum albiflorum				
Hieraceum cynoglossoides			X	
Hulsea algida				
Madia madioides				
Microseris alpestris				
Microseris troximoides			X	
Rudbeckia occidentalis				
Senecio hydrophilus				X
Senecio triangularis				X
Solidago canadensis				
Stephanomeria lactucina			X	
Taraxacum officinale	I			
Tragopogon dubius	I			
BERBERIDACEAE				
Berberis aquifolium				
Berberis nervosa				
Berberis repens				
Vancouveria hexandra		X		
BETULACEAE				
Alnus incana				X
Alnus sinuata				X
Betula glandulosa				X
Corylus cornuta				
BORAGINACEAE				
Cryptantha simulans			X	
Cryptantha torreyana				
Hackelia californica				
Plagiobothyrys mollis				
BRASSICACEAE				
Arabis divaricarpa				
Arabis holboellii				
Arabis platysperma				
Arabis suffrutescens				
Sisymbrium altissimum	I			
Subularia aquatica				
CAMPANULACEAE				
Campanula prenanthoides				
Campanula scouleri				
Downingia elegans				X
CAPRIFOLIACEAE				
Linnaea borealis		X		
Lonicera conjugialis				
Lonicera involucrata				X
Sambucus cerulea				
Sambucus racemosa				
Symphoricarpos mollis				
Symphoricarpos oreophilus				
CARYOPHYLLACEAE				
Arenaria congesta				
Arenaria kingii				
Arenaria macrophylla				
Silene antirrhina				
Silene douglasii				
Silene noctiflora				
Silene nuda ssp. insectivora	S			X
Spergula arvensis	I			
Stellaria longifolia				
CELASTRACEAE				
Pachistima myrsinites				

	Status	Habitat Associated With Late Seral	P. Pine	Wetland
CORNACEAE				
Cornus stolonifera				X
CRASSULACEAE				
Sedum oreganum				
CUSCUTACEAE				
Cuscuta indecora				X
DROSERACEAE				
Drosera anglica				X
Drosera rotundifolia				X
ERICACEAE				
Arctostaphylos nevadensis				
Arctostaphylos patula				
Chimaphila menziesii		X		
Chimaphila umbellata		X		
Gaultheria humifusa		X		
Gaultheria shallon				
Kalmia microphylla				
Menziesia ferruginea		X		X
Phyllodoce empetriformis				
Pterospora andromeda		X		X
Pyrola aphylla		X		
Pyrola asarifolia		X		X
Pyrola picta		X		
Pyrola secunda		X		
Vaccinium caespitosum				
Vaccinium membranaceum		X		
Vaccinium occidentale				X
Vaccinium parvifolium		X		X
Vaccinium scoparium				
FABACEAE				
Lathyrus nevadensis				X
Lotus micranthus			X	
Lupinus albicaulis				
Lupinus caudatus			X	
Lupinus lepidus				
Lupinus polyphyllus var. burkei				X
Trifolium eriocephalum				
Trifolium longipes				
Trifolium macrocephalum			X	
Trifoilium procumbens				X
Vicia americana				X
FAGACEAE				
Castanopsis chrysophylla				
FUMITORIACEAE				
Dicentra formosa				
Dicentra uniflora				
GENTIANACEAE				
Gentiana newberryi	S			
Gentiana simplex				
Menyanthes trifoliata				X
GERANIACEAE				
Geranium oreganum				X
Geranium viscosissimum				
GROSSULARIACEAE				
Ribes cereum				
Ribes cruentum				
Ribes erythrocarpum				
Ribes inerme				
Ribes lacustre				X
Ribes laxiflorum				
Ribes lobbii				
Ribes viscosissimum				
HIPPURIDACEAE				
Hippuris vulgaris *				X

		Habitat Associated With		
	Status	Late Seral	P Pine	Wetland
HYDROPHYLLACEAE				
Hydrophyllum capitatum				
Phacelia hastata				
Phacelia heterophylla				
Phacelia linearis				
Nama lobbii				
HYPERICACEAE				
Hypericum anagalloides				X
Hypericum formosum				X
Hypericum perforatum	NW			
LOASACEAE				
Mentzelia albicaulis				
MALVACEAE				
Sidalcea hirsuta				X
Sidalcea neomexicana				X
Sphaeralcea grossulariaefolia				
MENTHACEAE				
Mentha arvensis *				X
Mondardella odoratissima				
Nepeta cataria	I			
Prunella vulgaris	I			X
Scutellaria galericulata				X
Stachys rigida				X
MENYANTHACEAE				
Menyanthes trifoliata				X
NYMPHACEAE				
Nuphar polysepalum				X
ONAGRACEAE				
Clarkia lassenensis				
Clarkia rhomboidea			X	
Epilobium angustifolium				
Epilobium glabberimum				X
Epilobium glandulosum				
Epilobium minutum			X	
Epilobium paniculatum			X	
Gayophytum diffusum				
POLEMONIACEAE				
Collomia grandiflora			X	
Collomia mazama	C2	X		
Collomia tinctoria				
Gilia aggregata				
Navarretia divaricata				X
Phlox diffusa				
Polemonium californicum				X
POLYGONACEAE				
Eriogonum nudum				
Eriogonum pyrolaefolium				
Eriogonum umbellatum				
Eriogonum vimineum				
Polygonum bistortoides				X
Polygonum confertiflorum				
Rumex occidentalis				X
PORTULACACEAE				
Montia sibirica				X
PRIMULACEAE				
Dodecatheon alpinum				
RANUNCULACEAE				
Aconitum columbianum				X
Actaea rubra				
Anemone deltoidea				
Anemone oregana		X		
Aquilegia formosa				X
Delphinium nuttallianum			X	
Delphinium occidentale				
Ranunculus occidentalis				X

		Habitat Associated With		
	Status	Late Seral	P.Pine	Wetland
RHAMNACEAE				
Ceanothus prostratus				
Ceanothus velutinus				
Rhamnus alnifolia				
Rhamnus purshiana				
ROSACEAE				
Amelanchier alnifolia			X	
Fragaria vesca				
Fragaria virginiana				
Holodiscus discolor			X	
Horkelia fusca				
Luetkea pectinata				
Potentilla glandulosa				
Potentilla gracilis				X
Prunus emarginata				
Prunus virginiana				X
Purshia tridentata			X	
Rosa gymnocarpa				
Rosa nutkana				X
Rosa woodsii				X
Rubus lasiococcus		X		
Rubus parviflorus				
Rubus ursinus				
Sanguisorba occidentalis	I			
Sorbus scopulina				
Spiraea densiflora				
Spiraea douglasii				X
RUBIACEAE				
Galium aparine				
Galium boreale				X
Galium oreganum		X		
Galium trifidum				X
Kelloggia galioides				
SALICACEAE				
Populus tremuloides				X
Populus trichocarpa				X
Salix lasiandra				X
Salix lutea				X
Salix sitchensis				X
SAXIFRAGACEAE				
Heuchera cylindrica				
Mitella pentandra				
Saxifriga oregana				X
Saxifriga tolmiei				
Tiarella trifoliata		X		
SCROPHULARIACEAE				
Castilleja arachnoidea				
Castilleja miniata				X
Collinsia parviflora			X	
Cordylanthus viscidus				
Mimulus alsinoides				X
Mimulus breweri				X
Mimulus guttatus				X
Mimulus lewisii				
Mimulus moschatus				
Mimulus nanus				
Mimulus primuloides				X
Orthocarpus attenuatus				X
Orthocarpus imbricatus				
Orthocarpus luteus				X
Pedicularis groenlandica				X
Pedicularis racemosa				
Penstemon cinicola (procerus?)				X
Penstemon davidsonii				
Penstemon deustus				
Penstemon rupicola				

	Status	Late Seral	P Pine	Wetland
Verbascum thapsus	I			
Veronica americana				X
Veronica anagallis-aquatica				X
VALERIANACEAE				
Valeriana scouleri				
Valeriana sitchensis				
VIOLACEAE				
Viola adunca				X
Viola glabella		X		
Viola nuttallii			X	
Viola sempervirens				

Habitat Associated With

	Late Seral
FUNGI	
Agaricus augustus	
Agaricus campestris	
Agaricus crocodilinus	
Agaricus placomyces	
Agaricus silvaticus	
Agaricus subrutilescens	
Agaricus sylvicola	
Amanita calyptroderma	
Amanita flavoconia	
Amanita muscaria var. formosa	X
Amanita pantherina	X
Armillaria mellea	
Armillaria zelleri	
Boletus aurantiacus	
Boletus eastwoodiae	
Boletus edulis	X
Boletus mirabilis	X
Calbovista subsculpta	
Cantharellus cibarius	
Cantharellus clavatus	
Cantharellus floccosus	
Cantharellus infundibuliformis	
Cantharellus subalbidus	
Cantharellus tubaeformis	
Catathelasma imperialis	
Clavaria botrytis	
Clavaria gelatinosa	
Clitocybe aurantiaca	
Collybia acervata	
Coprinus comatus	
Cortinarius cinnamomeus	
Cortinarius elatior	
Cortinarius violaceus	X
Fomitopsis pinicola	
Fuscoboletinus ochraceoroseus	
Galerina autumnalis	
Ganoderma applanatum	
Helvella californica	
Helvella gigas	
Helvella infula	
Helvella lacunosa	
Hericium wierii	
Hydnum repandum	X
Hypholoma fascularia	
Laccaria laccata	X
Lactarius deliciosus	X
Lactarius rufus	
Lactarius sanguifluus	
Lactarius scrobiculatus	X

	Habitat Associated With Late Seral
Laetiporus sulphureus	
Leucoagaricus naucinus	
Leucoagaricus rachodes	
Lycoperdon perlatum	
Macowanites americanus	
Marasmius oreades	
Morchella angusticeps	
Morchella esculenta	
Naematoloma fasciculare	
Phaeocollybia scatesiae	
Pholiota squarrosa	
Pholiota squarrosoides	
Pholiota sqarrosa-adiposa	
Phylloporus rhodoxanthus	
Pleurotus ostreatus	
Pluteus magnus	
Polyporus caesius	
Ramaria botrytis	X
Ramaria formosa	X
Rozites caperata	
Russula rosacea	X
Sarcosphaeria coronaria	
Sparassis radicata	
Strobilurus trullisatus	
Stropharia ambigua	
Strop[haria hornmanni	
Suillus brevipes	
Suillus elegans	
Suillus luteus	
Togaria aurea	
Tricholoma pardinum	
Tricholoma magnivelare	X
Tyromyces caesius	
Tuber gibbosum	
Tyromyces chioneus	

Habitats:

Association of species with late seral, ponderosa pine, or wetland habitats is indicated by an X. Species associated with late seral stands are taken from the SAT and FEMAT reports. Most information on occurrence comes from vascular plant surveys of the Cherry Creek RNA and Cherry and Nannie planning areas. Information on fungi was obtained from a special forest product report prepared for the whole District. Some of the fungi species may not occur in the watershed area.

Species associated with ponderosa pine stands are the author's best guess, based on information in floras and observation. Because the fire regime has been so disrupted in this forest type, shrub and ground cover may have been significantly different in the past.

Species associated with the low elevation wetlands were recorded during various surveys. These include those inhabitating lodgepole pine swamps, wet meadows, and moist (vernally wet) meadows. Species marked with asterisks were recorded during a survey of marsh habitat south of the watershed area, but are likely to also occur in the watershed area.

Status Codes:

SP - Special status
S - R6 sensitive species list
C2 - Category 2 candidate for federal listing
I - Introduced
NW - Noxious Weed

Nomenclature follows Hitchcock and Cronquist (1973).

Appendix D. Source of Vegetation Data

Historical vegetation was determined from 1940's and 1950's aerial photographs of the watershed area. At that time, little harvesting had occurred except on the east side of Pelican Butte and the lower Cherry drainage. Stands had been delineated on the photos in the 1950's. Stand exam codes indicating species, tree diameter, and canopy cover had also been recorded. Using the information on the photos, stands were mapped at a scale of 1:24,000 and entered into GIS. The 1950's stand exam information was translated into codes used in the PMR (Pacific Meridian Resources) satellite data collecting system. Three characteristics of vegetation were coded: canopy closure, species, and size/structure of stands. Where data was missing from the photos, a stereoscope was used to extrapolate stand characteristics. The PMR codes were entered into an Oracle database so that maps of stand characteristics could be produced.

The historical data was compared to 1989 PMR data. Because the current data was recorded in 25m pixel form (the Forest will be getting the software for polygon conversion later this year) and the historical data is in polygon form, statistical comparisons of landscape spatial patterns were not valid. Only visual and rough acre comparisons could be made. It was decided to convert pixel data to 5-acre blocks for better visual comparison. Numerical comparisons were done with the original pixel data. A difference in habitat condition (e.g., percent of area in late seral structure) from 1940 to 1989 of 5% or less was considered insignificant.

Error in interpretation of some of the 1950 stand exam information is likely. Errors were partially mitigated by lumping several codes into broader categories when making comparisons. For example, canopy closure was analyzed by comparing <40%, 40-70%, and >70% categories and species were lumped into groups (mountain hemlock, red fir, white fir, ponderosa pine-dominated, lodgepole pine, grass, shrubs, rock, water). The current PMR species data contained many discrepancies. District knowledge about species distribution and recent stand exam information was compared with historical data instead.

Size/structure was combined into 4 categories: non-forested; early seral; mid seral; and late seral, regardless of species. This approach appears to best match treatments of seral stage in recent references, which rarely address change of species composition with succession and focus on stand structure. All of the lodgepole pine present fell into the early seral category because of its small diameter, although some stands may have been older. This error was considered insignificant because of the small amount of lodgepole pine present. In general, the following definitions were used: non-forested included rock, water, meadows, and wetlands (codes 1,2,4, and 9); early seral included brush and stands with pole-sized trees (5-9 inches DBH) or smaller (codes 5,10-12, and 20); mid seral stands included stands with small trees (9-21 inch DBH) (codes 13,14,21,22,23,24, and 27); and late seral stands included all stands with medium trees (21-32 inch DBH) or larger (codes 25,26,28, 31,32, and 34). There were a few exceptions. Stands with medium-sized trees which had been cut or had <40% canopy due to fire or poor site conditions were classified as mid seral. Multi-storied stands dominated by small trees, but with more canopy closure from medium and large trees, than seedling/sapling/pole trees (small multi-storied plus), were included in the late seral category.